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METALLURGICAL TABLES

USED AT THE

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NEW YORK.

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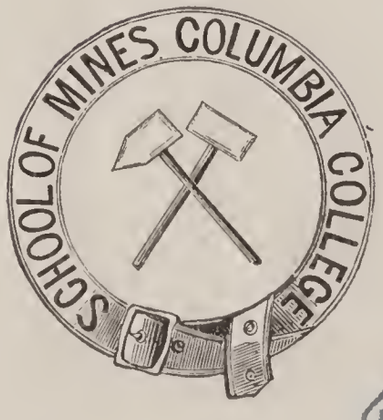
BY

T. EGLESTON, Jr.,

Professor of Mineralogy and Metallurgy.



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INTRODUCTION.

The following Tables comprise the illustrations of the Metallurgical Lectures for the years 1867–8. The measures which have been given are all of the Metrical System. Tables for their conversion into the measures in use in the U. S. have been prepared for the use of the Students.

The cost price has been given in francs, because most of the information with regard to cost, which was accessible, was given in that currency. The item of total cost has but a relative value; it is given only as a standard of comparison. The cost price of working by any process will vary in different localities. The composition of the charges, the amount of labor and materials used will be about the same under the same circumstances; and local variations, owing to the relations of capital to labor, and other causes, must be determined in particular cases.

Many valuable additions might be made to the tables. They have however been made as complete as it was possible to make them in the time which could be devoted to their preparation. It is hardly to be hoped that they are free from mistakes. These will be corrected and additions made in future editions.

THOS. EGLESTON, Jr.

School of Mines, May, 1868.

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ERRATA.

Plate 2, figs. 3, 5, 8, 9, the scale should be eight millimetres for one metre.

Plate 4, figs. 7, 8, 9, the scale should be one centimetre for one metre.

TABLES

OF

WEIGHTS, MEASURES, COINS, &c.,

WITH THEIR

EQUIVALENTS IN THE ENGLISH AND FRENCH SYSTEMS.

No. 1.—Avoirdupois Weight.

16 drachms	=	1 ounce.
16 ounces	=	1 pound.
28 pounds*	=	1 quarter.
4 quarters	=	1 hundred wt.
20 hundred wt.	=	1 ton of 2240lbs.

*In the U. S., with some exceptions,

100 pounds	=	1 hundred wt.
2000 pounds	=	1 ton.

No. 2.—Troy Weight.

24 grains	=	1 pennyweight.
20 pennyweights	=	1 ounce.
12 ounces	=	1 pound.

No. 3.—Apothecaries' Weight.

20 grains	=	1 scruple,	(℈)
3 scruples	=	1 dram,	(ʒ)
8 drams	=	1 ounce,	(℥)
12 ounces	=	1 pound,	(lb)

No. 4.—Wine Measure. U. S.

60 minims	=	1 fluidrachm, (fl ʒ)
8 fluidrachms	=	1 fluidounce, (fl ℥)
16 fluidounces	=	1 pint.
2 pints	=	1 quart.
4 quarts	=	1 gallon.
31½ gallons	=	1 barrel.
2 barrels	=	1 hogshead.

No. 5.—Imperial Wine Measure.

60 minims	=	1 fluidrachm.
8 fluidrachms	=	1 fluidounce.
20 fluidounces	=	1 pint.
2 pints	=	1 quart.
4 quarts	=	1 gallon.
9 gallons	=	1 firkin.
36 gallons	=	1 barrel.
54 gallons	=	1 hogshead.
2 hogsheads	=	1 pipe.
2 pipes	=	1 tun.

No. 6.—Dry Measure.

2 pints	=	1 quart.
8 quarts	=	1 peck.
4 pecks	=	1 bushel.

No. 7.—Length.

12 inches	=	1 foot.
3 feet	=	1 yard.
1760 yards	=	1 mile.
8 furlongs	=	1 mile.
3 miles	=	1 league.

No. 8.—Square Measure.

144 square inches	=1 square foot.
9 square feet	=1 square yard.
30¼ square yards	=1 sq. rod or perch
40 sq. rods or perches	=1 rood.
4 roods or 160 "	=1 acre.
640 acres	=1 square mile.

No. 9.—Cubic Measure.

1728 cubic inches	=	1 cubic foot.
27 cubic feet	=	1 cubic yard.
128 cubic feet	=	1 cord.

No. 10.—Federal Currency.

10 mills	=	1 cent.
10 cents	=	1 dime.
10 dimes	=	1 dollar.
10 dollars	=	1 eagle.

No. 11.—English Currency.

4 farthings	=	1 penny.
12 pence	=	1 shilling.
20 shillings	=	1 pound or sovereign.

No. 12.—French Currency.

5 centimes	=	1 sou.
100 centimes	=	1 franc.
20 francs	=	1 Napoleon.

DECIMAL SYSTEM.

No. 13.—Explanation of Prefixes.

For division, from the Latin.

Mille	=	1000
Centum	=	100
Decem	=	10

Gramme.	Metre.	Are.	Litre.
Weight.	*Length.*	*Surfaces.*	*Cub. Capacity.*

For multiplication.

Δεκα (Deca)	=	10
Ἑκατον (Hecaton)	=	100
Χιλιος (Chilios)	=	1000
Μυριας (Myrias)	=	10000

No. 14.—Weight.

.001 of a gramme	=	1 milligramme.
.01 " "	=	1 centigramme.
.1 " "	=	1 decigramme.
1 cubic centimetre of water at 4°C	=	1 gramme.
10 grammes	=	1 decagramme.
100 "	=	1 hectogramme.
1000 "	=	1 kilogramme.
100 kilogrammes	=	1 quintal.
1000 "	=	1 ton.

No. 15.—Wet Measure.

.01 of a cubic metre	=	1 centilitre.
.1 " "	=	1 cubic decimetre.
1 "	=	1 litre.
10 "	=	1 decalitre.
100 "	=	1 hectolitre.
1000 "	=	1 kilolitre.

No. 16.—Measures of Length.

.001 of a metre	=	1 millimetre.
.01 " "	=	1 centimetre.
.1 " "	=	1 decimetre.
1 metre	=	1 ten-millionth of the distance from the pole to the equator.
10 metres	=	1 decametre.
100 "	=	1 hectometre.
1000 "	=	1 kilometre.
10,000 "	=	1 myriametre.

No. 17.—Measures of Surface.

1 square metre	=	1 centiare.
100 " "	=	1 are.
10,000 " "	=	1 hectare.

No. 18.—Solid Measure.

.1 of a cubic metre	=	1 cubic decimetre.
1 cubic metre	=	1 stere.
10 cubic metres	=	1 cubic decametre.

No. 19.—Relative Value of Troy and Avoirdupois Weights.

Pound.		Pounds.		Pound.	Ounces.	Grains.
1 troy	=	0.822857 avoirdupois	=	0	13	72.5
1 avoirdupois	=	1.215277 troy	=	1	2	280.

No. 20.—Relative Value of U. S. Wine and Imperial Wine Measure.

U. S. Wine Measure.									Imperial Wine Measure.
1 minim	=								1.04 minims.
1 fluidrachm	=					1	fluidrachms,	2.5	"
1 fluidounce	=			1	fluidounces,	0	"	20	"
1 pint	=		16	"		5	"	18	"
1 gallon	=	6 pints,	13	"		2	"	23	"

Imperial Wine Measure.									U. S. Wine Measure.
1 minim	=								0.96 minims.
1 fluidrachm	=							58	"
1 fluidounce	=					7	fluidrachms,	41	"
1 pint	=		1 pint,	3	fluidounces,	1	"	38	"
1 gallon	=	1 gallon,	1 "	9	"	5	"	8	"

VALUE OF ENGLISH WEIGHTS AND MEASURES IN FRENCH.

No. 21.—Avoirdupois Weight.

1 dram	=	1.7718 gram's
1 ounce	=	28.3464 "
1 pound	=	0.45359265 k.
1 hundredwt. 100 lbs	=	45.359265 "
1 ton, 2000 lbs.	=	907.18530 "
1 ton, 2240 lbs.	=	1016.0416 "

No. 22.—Troy Weight.

1 grain	=	0.0648 grammes.
1 pennyweight	=	1.5545 "
1 ounce	=	31.0813 "
1 pound	=	373.241918 "

No. 23.—Apothecaries' Weight.

1 grain	=	0.0648 grammes.
1 scruple	=	1.296 "
1 dram	=	3.8779 "
1 ounce	=	31.1035 "
1 pound	=	373.242 "

No. 24.—Wine Measure. U. S.

1 minim	=	0.0000616 litres.
1 fluidrachm	=	0.003697
1 fluidounce	=	0.029578
1 pint	=	0.47325
1 quart	=	0.9465
1 gallon	=	3.786
1 barrel	=	129.249
1 hogshead	=	258.498

No. 25.—Imperial Wine Measure.

1 minim	=	0.00005915 litres.
1 fluidrachm	=	0.0035495
1 fluidounce	=	0.0283966
1 pint	=	0.567932
1 quart	=	1.135864
1 gallon	=	4.543458
1 barrel	=	163.5642
1 hogshead	=	245.3436
1 pipe	=	490.6872
1 tun	=	981.3744

No. 26.—Dry Measure. U. S.

1 pint	=	0.55067 litres.
1 quart	=	1.10135
1 peck	=	8.8108
1 bushel	=	35.2432

No. 27.—Long Measure.

1 inch	=	2.54 centimetres.
1 foot	=	0.3048 metres.
1 yard	=	0.9144 "
1 rod	=	5.0297 "
1 furlong	=	201.1643 "
1 mile	=	1609.3149 "

No. 28.—Square Measure.

1 square inch	=	6.49 sq. centimetres.
" foot	=	0.0929 sq. metres.
" yard	=	0.8360 "
" rod	=	25.292 "
" rood	=	10.1168 ares.
" acre	=	40.4671 "
" mile	=	258.9894 hectares.

No. 29.—Cubic Measure.

1 cu. inch	=	16.3862 cu. centimetres.
1 cu. foot	=	28315.3119 " "
1 cu. yard	=	0.764513 cu. metres.

No. 30.—UNITED STATES.

		VALUE. Francs.	FINENESS.	VARIATION	WEIGHT. Grammes.
GOLD.					
Double eagle,	$20	103.40	90 per c.	0.002	33.434
Eagle,	$10	51.70	"	"	16.717
Half eagle,	$5	25.85	"	"	8.385
3 dollars,	$3	15.51	"	"	5.01
2½ dollars,	$2.50	12.925	"	"	4.179
1 dollar,	$1	5.17	"	"	1.67
SILVER.					
1 dollar,	$1	5.17	"	0.003	26.729
Half dollar,	50c.	2.585	"	"	13.364
¼ dollar,	25c.	1.2925	"	"	6.682
Dime,	10c.	0.517	"	"	2.672
Half dime,	5c.	0.2585	"	"	1.336
3 cents,	3c.	0.1551	"	"	0.8076
NICKEL.			BRONZE.		
5 cents,	5c.		1 cent,	1c.	
3 cents,	3c.		2 cents,	2c.	

No. 31.—ENGLAND.

GOLD.					
Five pounds,	£5	125.00	91.6 per c.	0.002 2/4 8	
Sovereign,	£1	25.00	"	"	7.981
Half sovereign.	½s.	12.50	"	"	3.995
SILVER.					
Crown,	5s.	6.25	92.5 per c.	0.004 1/6	28.250
Half crown.	2s. 6d.	3.125	"	"	14.125
Florin,	2s.	2.50	"	"	11.300
Shilling,	1s.	1.25	"	"	5.650
Sixpence,	6d.	0.625	"	"	2.825
4 pence (groat)	4d.	0.4166	"	"	1.883
3 pence,	3d.	0.3125	"	"	1.412
2 pence,	2d.	0.2083	"	"	0.941
1 penny,	1d.	0.1041	"	"	0.470
BRONZE.					
Penny,	1d.				
Halfpenny,	½d.				
Farthing,	¼d.				

No. 32.—FRANCE.

					DIAMETER
GOLD.					
100 francs.	100	90 per c.	0.002	32.25806	35m.m.
50 "	50	"	"	16.12903	28
20 "	20	"	"	6.45161	21
10 "	10	"	"	3.2258	19
5 "	5	"	"	1.61290	17
SILVER.					
5 francs.	5	"	0.003	25. "	37
2 "	2	83.5 per c.	"	10. "	27
1 "	1	"	"	5. "	23
0.50	0.50	"	"	2.50	18
0.20	0.20	"	"	1	15
BRONZE.					
0.10	0.10			10.	30
0.05	0.05			5.	25
0.02	0.02			2.	20
0.01	0.01			1.	15

EQUIVALENTS OF ENGLISH AND FRENCH WEIGHTS & MEASURES.

I.

Avoirdupois Ounces.		Grammes.	Hectogrammes.		Avoirdupois Ounces.
1	=	28.35	1	=	3.53
2	=	56.70	2	=	7.06
3	=	85.05	3	=	10.59
4	=	113.40	4	=	14.12
5	=	141.75	5	=	17.65
6	=	170.10	6	=	21.18
7	=	198.45	7	=	24.71
8	=	226.80	8	=	28.24
9	=	255.15	9	=	31.77

II.

Avoirdupois Pounds		Kilogrammes.	Kilogrammes.		Avoirdupois Pounds.
1	=	.4536	1	=	2.2
2	=	.9072	2	=	4.4
3	=	1.3608	3	=	6.6
4	=	1.8144	4	=	8.8
5	=	2.2680	5	=	11.0
6	=	2.7216	6	=	13.2
7	=	3.1752	7	=	15.4
8	=	3.6228	8	=	17.6
9	=	4.0824	9	=	19.8

III.

Grains.		Milligrammes.	Grammes.		Grains.
1	=	64.8	1	=	15.43
2	=	129.6	2	=	30.86
3	=	194.4	3	=	46.29
4	=	259.2	4	=	61.72
5	=	324.0	5	=	77.15
6	=	388.8	6	=	92.58
7	=	453.6	7	=	108.01
8	=	518.4	8	=	123.44
9	=	583.2	9	=	138.87

IV.

Troy ounces.		Grammes.	Hecto rammes.		Troy ounces.
1	=	31.1	1	=	3.2
2	=	62.2	2	=	6.4
3	=	93.3	3	=	9.6
4	=	124.4	4	=	12.8
5	=	155.5	5	=	16.0
6	=	186.6	6	=	19.2
7	=	217.7	7	=	22.4
8	=	248.8	8	=	25.6
9	=	279.9	9	=	28.8

V.

Troy Pounds.		Kilogrammes.	Kilogrammes.		Troy Pounds.
1	=	.373	1	=	2.7
2	=	.746	2	=	5.4
3	=	1.119	3	=	8.1
4	=	1.492	4	=	10.8
5	=	1.865	5	=	13.5
6	=	2.238	6	=	16.2
7	=	2.612	7	=	18.9
8	=	2.984	8	=	21.6
9	=	3.357	9	=	24.3

VI.

Fluid Drachms.		Cubic Centimetres.	Cubic Centimetres.		Fluid Drachms
1	=	3.7	1	=	.27
2	=	7.4	2	=	.54
3	=	11.1	3	=	.81
4	=	14.8	4	=	1.08
5	=	18.5	5	=	1.35
6	=	22.2	6	=	1.62
7	=	25.9	7	=	1.89
8	=	29.6	8	=	2.16
9	=	33.3	9	=	2.43

VII.

Fluid Ounces.		Cubic Centimetres.	Litres.		Fluid Ounces.
1	=	30	1	=	33.8
2	=	60	2	=	67.6
3	=	90	3	=	101.4
4	=	120	4	=	135.2
5	=	150	5	=	169.0
6	=	180	6	=	202.8
7	=	210	7	=	236.6
8	=	240	8	=	270.4
9	=	270	9	=	304.2

VIII.

Pints.		Litres.	Litres.		Pints.
1	=	.473	1	=	2.1
2	=	.946	2	=	4.2
3	=	1.419	3	=	6.3
4	=	1.892	4	=	8.4
5	=	2.365	5	=	10.5
6	=	2.838	6	=	12.6
7	=	3.311	7	=	14.7
8	=	3.784	8	=	16.8
9	=	4.257	9	=	18.9

IX.

Gallons.		Litres.	Litres.		Gallons.
1	=	3.78	1	=	.264
2	=	7.56	2	=	.528
3	=	11.34	3	=	.792
4	=	15.12	4	=	1.056
5	=	18.90	5	=	1.320
6	=	22.68	6	=	1.584
7	=	26.46	7	=	1.848
8	=	30.24	8	=	2.112
9	=	34.00	9	=	2.376

X.

Pecks.		Litres.	Litres.		Pecks
1	=	8.8	1	=	.23
2	=	17.6	2	=	.46
3	=	26.4	3	=	.69
4	=	35.2	4	=	.92
5	=	44.0	5	=	1.15
6	=	52.8	6	=	1.38
7	=	61.6	7	=	1.61
8	=	70.4	8	=	1.84
9	=	79.2	9	=	2.07

XI.

Bushels.		Litres.	Hectolitres.		Bushels.
1	=	35.	1	=	2.8
2	=	70.	2	=	5.6
3	=	105.	3	=	8.4
4	=	140.	4	=	11.2
5	=	175.	5	=	14.0
6	=	210.	6	=	16.8
7	=	245.	7	=	19.6
8	=	280.	8	=	22.4
9	=	315.	9	=	25.2

XII.

Inches.		Millimetres.	Millimetres.		Inches.
1	=	25.4	1	=	.03937
2	=	50.8	2	=	.07874
3	=	76.2	3	=	.11811
4	=	101.6	4	=	.15748
5	=	127.	5	=	.19685
6	=	152.4	6	=	.23622
7	=	177.8	7	=	.27559
8	=	193.2	8	=	.31496
9	=	228.6	9	=	.35433

XIII.

Feet.		Metres.	Metres.		Feet.
1	=	.3048	1	=	3.28
2	=	.6096	2	=	6.56
3	=	.9144	3	=	9.84
4	=	1.2192	4	=	13.12
5	=	1.5240	5	=	16.40
6	=	1.8288	6	=	19.68
7	=	2.1336	7	=	22.96
8	=	2.4384	8	=	26.24
9	=	2.7432	9	=	29.52

XIV.

Yards.		Metres.	Metres.		Yards.
1	=	.9144	1	=	1.1
2	=	1.8288	2	=	2.2
3	=	2.7432	3	=	3.3
4	=	3.6576	4	=	4.4
5	=	4.5720	5	=	5.5
6	=	5.4864	6	=	6.6
7	=	6.4008	7	=	7.7
8	=	7.3152	8	=	8.8
9	=	8.2296	9	=	9.9

XV.

Miles.		Kilometres.	Kilometres.		Miles.
1	=	1.61	1	=	.62
2	=	3.22	2	=	1.24
3	=	4.83	3	=	1.86
4	=	6.44	4	=	2.48
5	=	8.05	5	=	3.10
6	=	9.66	6	=	3.72
7	=	11.27	7	=	4.34
8	=	12.88	8	=	4.96
9	=	14.49	9	=	5.58

XVI.

Square Inches.		Square Centimetres.	Square Centimetres.		Square Inches.
1	=	6.49	1	=	0.154
2	=	12.98	2	=	0.308
3	=	19.47	3	=	0.462
4	=	25.96	4	=	0.616
5	=	32.45	5	=	0.770
6	=	38.94	6	=	0.924
7	=	45.43	7	=	1.078
8	=	51.92	8	=	1.232
9	=	58.41	9	=	1.386

XVII.

Sq. Feet.		Sq. Metres.	Sq. Metres.		Sq. Feet.
1	=	.093	1	=	10.7
2	=	.186	2	=	21.4
3	=	.279	3	=	32.1
4	=	.372	4	=	42.8
5	=	.465	5	=	53.5
6	=	.558	6	=	64.2
7	=	.651	7	=	74.9
8	=	.744	8	=	85.6
9	=	.837	9	=	96.3

XVIII.

Sq. Yards.		Sq. Metres.	Sq. Metres.		Sq. Yards.
1	=	0.836	1	=	1.196
2	=	1.672	2	=	2.392
3	=	2.508	3	=	3.588
4	=	3.344	4	=	4.784
5	=	4.180	5	=	5.980
6	=	5.016	6	=	7.176
7	=	5.852	7	=	8.372
8	=	6.688	8	=	9.568
9	=	7.524	9	=	10.764

XIX.

Acres.		Hectares.	Hectares.		Acres.
1	=	.4	1	=	2.47
2	=	.8	2	=	4.94
3	=	1.2	3	=	7.41
4	=	1.6	4	=	9.88
5	=	2.0	5	=	12.35
6	=	2.4	6	=	14.82
7	=	2.8	7	=	17.29
8	=	3.2	8	=	19.76
9	=	3.6	9	=	22.23

XX.

Cub. Inches.		Cub. Centim.	Litres.		Cub. Inches
1	=	16.39	1	=	61.
2	=	32.78	2	=	122.
3	=	49.17	3	=	183.
4	=	65.56	4	=	244.
5	=	81.95	5	=	305.
6	=	98.34	6	=	366.
7	=	114.73	7	=	427.
8	=	131.12	8	=	488.
9	=	147.51	9	=	549.

XXI.

Cubic Feet.		Litres.	Hectolitres.		Cubic Feet.
1	=	28.3	1	=	3.5
2	=	56.6	2	=	7.0
3	=	84.9	3	=	10.5
4	=	113.2	4	=	14.0
5	=	141.5	5	=	17.5
6	=	169.8	6	=	21.0
7	=	198.1	7	=	24.5
8	=	226.4	8	=	28.0
9	=	254.7	9	=	31.5

XXII.

Yards.		Cu. Metres.	Cu. Metres.		Cu. Yards.
1	=	.7645	1	=	1.3
2	=	1.529	2	=	2.6
3	=	2.2935	3	=	3.9
4	=	3.0580	4	=	5.2
5	=	3.8225	5	=	6.5
6	=	4.5870	6	=	7.8
7	=	5.3515	7	=	9.1
8	=	6.1160	8	=	10.4
9	=	6.8805	9	=	11.7

XXIII.

Dollars.		Francs.	Francs.		Dollars.
1	=	5.17	1	=	0.1934
2	=	10.34	2	=	0.3868
3	=	15.51	3	=	0.5792
4	=	20.68	4	=	0.7736
5	=	25.85	5	=	0.9670
6	=	31.02	6	=	1.1604
7	=	36.19	7	=	1.3538
8	=	41.36	8	=	1.5472
9	=	46.53	9	=	1.7406

XXIV.

Pounds.		Francs.	Francs.		Pounds.
1	=	25	1	=	0.04
2	=	50	2	=	0.08
3	=	75	3	=	0.12
4	=	100	4	=	0.16
5	=	125	5	=	0.20
6	=	150	6	=	0.24
7	=	175	7	=	0.28
8	=	200	8	=	0.32
9	=	225	9	=	0.36

XXV.

Shillings.		Francs.	Francs.		Shillings.
1	=	1.25	1	=	0.80
2	=	2.50	2	=	1.60
3	=	3.75	3	=	2.40
4	=	5.00	4	=	3.20
5	=	6.25	5	=	4.00
6	=	7.50	6	=	4.80
7	=	8.75	7	=	5.60
8	=	10.00	8	=	6.40
9	=	11.25	9	=	7.20

XXVI.

Pence.		Francs.	Francs.		Pence.
1	=	0.104166	1	=	9.6006
2	=	0.208333	2	=	19.2012
3	=	0.312499	3	=	28.8018
4	=	0.416666	4	=	38.4024
5	=	0.520833	5	=	48.0030
6	=	0.624999	6	=	57.6036
7	=	0.729166	7	=	67.2042
8	=	0.832322	8	=	76.8048
9	=	0.937499	9	=	86.4054

XXVII.

Cent.		Fah.	Fah.		Cent.
1	=	1.8	1	=	.555
2	=	3.6	2	=	1.110
3	=	5.4	3	=	1.665
4	=	7.2	4	=	2.220
5	=	9.0	5	=	2.775
6	=	10.8	6	=	3.330
7	=	12.6	7	=	3.885
8	=	14.4	8	=	4.440
9	=	16.2	9	=	4.995

To change F. into C. use the table and add 32.
To change C. into F. subtract 32 and use the table.

XXVIII.

Inches Height.		Pounds.	Pounds.		Inches Height.
1	=	0.491963	1	=	2.03267
2	=	0.983926	2	=	4.06534
3	=	1.475889	3	=	6.09801
4	=	1.967852	4	=	8.13068
5	=	2.459815	5	=	10.16335
6	=	2.951778	6	=	12.19602
7	=	3.443741	7	=	14.22869
8	=	3.935704	8	=	16.26136
9	=	4.427667	9	=	18.29403

XXIX.

Cent. Mercury.		Pounds.	Pounds.		Cent. Mercury.
1	=	0.19371	1	=	5.16234
2	=	0.38742	2	=	10.32468
3	=	0.58113	3	=	15.48702
4	=	0.77484	4	=	20.64936
5	=	0.96855	5	=	25.81170
6	=	1.16226	6	=	30.97404
7	=	1.35597	7	=	36.13638
8	=	1.54968	8	=	41.29872
9	=	1.74339	9	=	46.46106

XXX.

Ht. Mercury.		Ht. Water.	Ht. Water.		Ht. Mercury.
1 c.m.	=	13.58*	1 c.m.	=	0.074374
2 "	=	27.16	2 "	=	0.148748
3 "	=	40.74	3 "	=	0.223122
4 "	=	54.32	4 "	=	0.297496
5 "	=	67.90	5 "	=	0.371870
6 "	=	81.48	6 "	=	0.446244
7 "	=	95.06	7 "	=	0.520618
8 "	=	108.64	8 "	=	0.594992
9 "	=	122.22	9 "	=	0.669366

*The density of mercury is taken at 60°

METALLURGICAL TABLES

USED AT THE

SCHOOL OF MINES,

COLUMBIA COLLEGE,

NEW YORK.

ORES OF COPPER.

Native Copper.

Copper,	Cu.	1

Oxydes.

Red Copper,	ċu.	1
Cu, 88.8		
O, 11.2		
Melaconite,	Ċu.	1?
Cu, 79.85		
O, 20.15		
Carro-Carro, Mixture of Cu & Ċu.		

Silicate and Oxychloride.

Chrysocolla,	$\dot{C}u^3\ddot{S}i^2+6\dot{H}$.	
Ċu, 45.2		
S̈i, 34.3		
Ḣ, 20.5		
Atacamite,	CuCl+3ĊuḢ.	3
Ċu, 55.8		
CuCl, 31.5		
Ḣ, 12.7		

Carbonates.

Malachite,	$\dot{C}u^2\ddot{C}+\dot{H}$	4
Ċu, 71.9		
C̈, 19.9		
Ḣ, 8.2		
Azurite,	$2\dot{C}u\ddot{C}+\dot{C}u\dot{H}$	4
Ċu, 69.2		
C̈, 25.6		
Ḣ, 5.2		

Compounds with S, without As or Sb.

Copper Glance,	CuS	3
Cu, 79.8		
S, 20.2		
Chalcopyrite,	$CuS+Fe^2S^3$	2
S, 34.9		
Cu, 34.6		
Fe, 30.5		
Erubescite,	2CuS+FeS	1
S, 23.7		
Cu, 62.5		
Fe, 13.8		
Cyanosite,	$\dot{C}u\ddot{S}+5\dot{H}$	5
S̈, 32.1		
Ċu, 31.8		
Ḣ, 36.1		

Compounds with S, containing As, Sb, or both.

Tetrahedrite,	(Cu,Fe,Zn,As),S+ $\frac{1}{4}$(Sb,As)S^3	1
Bournonite,	$(Cu,Pb)S+\frac{1}{3}Sb^2S^3$	3

Mansfield Slate, Mixture of pyrites and blende.

Phosphates and Arseniates.

TREATMENT OF NATIVE COPPER.

LAKE SUPERIOR.

No. 1.—Treatment.

1st, Fusion, fining, and refining in a reverberatory furnace.
2d, Fusion of the rich slags in a shaft furnace.
3d, Refining the copper from the shaft furnace in a reverberatory furnace.

No. 2.—Dimensions of the Reverberatory Furnace.

Fireplace	1.30 × 1.00
Height of bridge above grate	1.00
" from grate to roof	1.50
" of ash-pit	1.50
Width of bridge at fireplace	1.30
" hearth	2.00
Depth of bridge	0.60
Height from bridge to roof	0.45
Length of hearth	4.20
Width "	3.00
Gr'test depth of hearth below bridge	0.35
Thickness of hearth	1.00 to 0.60
" arch supporting hearth,	0.50
Opening in the roof	1.0 × 1.0
Inclination of hearth	4° to 5°
Flues	0.35 to 0.37
Height of chimney	18.0
Section of " at base	0.70 × 0.70
" " " " top	0.62 × 0.62
Charge	5000k. to 5500k.
Time to fusion	12 to 15 hours.
Number of operations per week	6 to 7

No. 3.—Details of the Fusion.

The following is the result at the Portage Works for 1859 and 1860:

13.605k. of coal at 17.22	258.30
Charcoal	10.50
16 men at 7.95	127.50
Repairs to furnaces and tools	12.25
	408.55f.
First fusion yields	6639.24k.
A ton costs	64.40f.

No. 4.—Details of the Shaft Furnace.

Diameter of the tuyeres	0.035
Pressure of blast	0.09 of Hg.

No. 5.—Cost of the Treatment of the Slag.

Picking of the scoriæ	0.85
Wood and charcoal	1.30
Anthracite	11.25
Flux	1.70
Fuel and repairs to blast engine	1.25
Labor at furnace during year	3.75
Repairs to cupola	0.35
	20.45f.

No. 6.—First Fusion.

In reverberatory furnace	10884k.
Fusion of scoriæ in shaft furnace,	4244.76
Second fusion in reverberatory furnace	424.47

The yields corresponding to these are as follows:

Yield.	*Weight.*	*Cost per ton.*
61%	6639.24	408.25
10%	424.47	95.74
8%	339.57	16.84
		520.83f.
	By ton of weight,	74.66f.

No. 7.—Dimensions of cupola in Native Copper Works; when anthracite is substituted by wood.

Fire-place	1.55 × 1.00
Grate below bridge	1.30
Section of lower part of chimney.	1.55 × 1.30
" upper " "	1.50 × 0.90
Height of chimney	5.00

FRANCE.

No. 1.—Composition of "Carro-Carro."

Cu	70.78
Cu	6.90
Fe	0.50
Sand	21.62
	99·80

No. 2.—Dimensions of the furnaces and elements of the charge in "Carro-Carro Works."

Fire-place	1.0 × 1.0
Major axis of hearth	2.27
Minor " "	1.27

Width of bridge.....0.87
Section of chimney.....0.80 × 0.80

No. 3.—*A charge is made up of*

	Tons.
"Carro-Carro"	1.400
Scoriæ	0.100
Slaked Lime	0.120

No. 4.—*Details for* 1856.

In furnace No. II. In 21 days.

	Tons.
Carro-Carro reduced.....	31.217
Copper produced,	24.055=77.06%
Coal consumed.....	7.420

In furnace No. III. In 27 days.

	Tons.
Carro-Carro reduced	55.867
Copper produced,.....	43.720=77.44%
Coal consumed.	10.962

No. 5.—*Slags.*

The slags from fining and refining contain 15 to 18% of Cu. They are refused in a cupola, with 12% of marl. 6,000t. to 7,000t. of slags are smelted in 24h. The following gives average composition of these slags for the years.

	1855.	1856.	1857.
Si.....	53.00	55.82	53.06
Al	15.50	7.20	9.40
Ca	16.85	29.12	30.60
Mg	0.10	0.06	0.10
Fe	14.00	7.00	5.58
Cu	0.55	0.80	1.26
	100.00	100.00	100.00

TREATMENT OF SULPHURETS OF COPPER.

PURE ORES.

I. GERMAN OR SWEDISH METHOD.

II. ENGLISH METHOD.

SWEDISH METHOD.

No. 1.—*Treatment.*

1. Roasting sulphurets.
2. Fusion for bronze mattes.
3. Roasting bronze mattes.
4. Fusion for black copper.
5. Fining.
6. Refining.

(1.) ROASTING.

No. 2.—*Roasting Pile.*

At Atoida.

Size of the pile, 6m. × 6m.
Height of the pile, 2.50 to 3.

In Norway.

Length of the pile, 20m.
Width " 6 to 7

No. 3.—*Arrangement of Pile.*

1st	bed of fuel (wood)	0.30
2d	" " (charcoal).....	0.10
1st	" ore	0.60
3d	" fuel.....	0.30
2d	" ore	0.40
4th	" fuel.....	0.30
3d	" ore	0.40
Covering of fine ore.....		0.10
		2.50

No. 4.—*Cost of Roasting in Piles.*

At Fahlun, 0.260st. or 87k. of wood per 1k. of ore.
At Atoida, 0.240k. and 30st. of charcoal or 80k. of wood per 1k. of ore.

Cost of roasting one ton.

0.25 st. of wood at 1. =0.25
0.4 day at 1.1=0.44
0.69

No. 5.—Ore Roasted in Pits.

0.29st. or 97k. of wood per the ton of ore.

No. 6.—Cost of Roasting at Roraas, in 1851.

Ore roasted	20954.24t.
Wt. of ore after roasting	19009.20t.
Wood used	312.80st.
Labor	943.22
Per ton of ore.	
Wood, 0.149 at 0.93	0.139
Labor	0.450
	0.589

(2.) FUSION FOR BRONZE MATTES.

No. 1.—Fusion Furnace at Roraas.

Height	4.70
Width in direction of the blast	.70
" perpendicular to "	.60
Greatest width	.80
Distance between the tuyeres	.31
Tuyeres above the bottom	.94
Nose	0.15 to 0.22

No. 2.—Fusion Furnace, 1848.

Height	5.34
Width of hearth	1.08
Depth of "	1.58
Width at tuyeres	1.13
" at 2.37 from hearth	1.19
" at throat	1.04
Depth at tympe to 1.63 above	0.79
Depth at throat	0.55
No. of tuyeres	3
Height of tuyeres above hearth	1.19
" " above tympe	0.45
Diameter of tuyeres	0.18

No. 3.—Fusion Furnace, 1851.

Height	7.12
From hearth to bosh	2.97
" " to tuyeres	1.19
" " to tympe	0.74
Width at the bottom of hearth	1.08
" " tuyeres	1.19
" 2.37 above hearth	1.78
Depth at hearth	1.63
" tympe	0.74
" 2.37 from the hearth	0.74
" at throat	0.52

No. 4.—Price of Labor.

Founder is paid 1.82f. per 12 hrs.
Charger " 1.26 " "
If in 12 posts they do not melt 573 m. q., they are fined.

No. 5.—Limits of Richness of the Mattes.

Cu	8. to 20.0
Fe	50. " 62.0
S	24. " 26.0
Zn	1. " 3.0
Pb	0. " 0.5

No. 6.—General Composition of the Mattes.

Cu	14 to 19
Fe	58 " 57
S	28 " 24

No. 7.—General Composition of the Slags.

$\ddot{S}i$	38 to 49
$\dot{F}e$	37 " 54
Bases	12 " 14

No. 8.—Charge used.

Charcoal	.51c.m.
Ore	.42 c.m. 2.62m.q.
Scoriæ	.10

No. 9.—Fuel used.

1st	post,	6.29c.m.
2d	"	7.99
3d	"	8.5
4th	"	7.65
5th	"	8.67
6th	"	8.84
7th	"	8.5
8th	"	8.9
9th	"	9.08
10th	"	8.67
11th	"	9.88
12th	"	8.91
13th	"	0.51

No. 10—Crystallized Slags from Sweden.

		Oxygen.
$\ddot{S}i$	44.9	23.3
$\dot{F}e$	48.7 —13.9	
$\ddot{A}l$	1.60— 7.5	22.9
$\dot{M}g$	3.7 — 1.5	
	98.9	

S̈i	47.1	24.4
Ḟe	37.7—10.8	
Ṁn	2.3— 0.5	16.3
Ä̇l	5.7— 2.7	
Ṁg	5.7— 2.3	
	98.5	

No. 11.—*Compact Slag from Sweden.*

		Oxygen.
S̈i	38.0	19.7
Ḟe	54.7—15.6	
Ä̇l	0.8— 0.4	18.2
Ṁg	5.4— 2.1	
Ċa	0.7— 0.1	

No. 12.— *Scoria from the Front Hearth.*

Scoria.	S̈i	19.5
	Ḟe	51.8
	Ṁg	4.8
	Ċa	5.3
	Ä̇l	2.6
Matte.	CuS	0.8
	ZnS	1.5
	FeS	11.3
		97.6

No. 13.—*Composition of Loupe.*

Fe	80.5	Loupe.
Cu	2.5	
Co	0.3	
S	1.4	
S̈i	8.3	Scoria.
Ċa	1.1	
Ṁg	1.5	
Ṁn	3.0	
	98.6	

No. 14.—*a.—Examples of Charges.*

At the Græfenberg Works.

Charge	Ore yielding 3%.....	68
	Forge scoriæ & scoriæ from blk. Cu.....	13
	Limestone.....	19
		100

b.—At Fahlun.

	No. 1	No. 2	No. 3
Quartzose ore 3%	44	14	54
Roasted do.	26	76	39
Scoriæ from blk. Cu.	30	10	7

c.—In Prismatic furnaces.

No. 1. 6.350t. smelted in 24 hours.
338k. of fuel for 1 ton.
No. 2. 9.250t. smelted in 24 hours.
175k. of fuel for 1 ton.

d.—In Furnace narrowed at the top.

No. 3. 6.500t. smelted in 24 hours.
249k. of fuel for 1 ton.
Matte yields 14% of copper, and is 17% of the charge.

e.—At Atoida.

Furnace, 2.50 to 3.90 high.
Quartzose ore 5%..... 30
Roasted do..... 70
Scoriæ of blk. Cu .... 8 to 10
Quantity melted..... 4t.
Fuel used.....290k.

f.—1844 to 1848.

Furnaces, 6 to 7m. high.
Quartzose ore..... 13k.
Roasted do..... 27
Rich roasted scoriæ... 40
Debris of furnaces.... 10
Scoriæ of blk. Cu.... 10
100
Quantity smelted.....8t. to 10t.
Fuel used.....236k.
Matte 18% of the weight of the ore and contains 20 to 21% Cu.

g.—At Roraas, 1851.

Ore 5%.....262
Scoriæ of blk. Cu.....120
Quantity of fuel..... 50 to 76
" smelted..... 9t. " 10t.
Matte 30% of charge.

No. 15.—*Cost at Roraas*, 1851.

300k. of fuel, 33f.		9.90
0.6 days at	1.45	.87
0.9 "	1.12	0.34
		11.11f.

No. 16.—*Quantity Smelted at Roraas in* 1851.

Quantity of raw ore..	21672.76t.
Weight of the matte.	6580.80k.
Quantity of fuel.....	4345.20c.m.
Labor	3584.88

(3.) ROASTING THE BRONZE MATTE.

No. 1.—*Dimensions of the Stalls at Roraas.*

Number of stalls	48
Width	1.25
Length	2.17
Height.....	1.50
Thickness of wall between stalls	0.60

No. 2.—*Fires Required for Roasting Mattes.*

40 to 50% of Cu. require 15 to 20 fires.
5 " 10 " " " 4 to 5 "
At Roraas 15 to 20% of Cu. require 7 fires.
" Atoida 18 " " 6 "
" Fahlun 4 to 9 " " 4 "

No. 3.—*Time for Roasting.*

At Roraas	7 fires last	20 days.
" Atoida	7 fires last	30 "
" Fahlun	7 fires last	40 to 50 "

No. 4.—*Cost of Roasting at Atoida.*

1.5st. of wood at	1.0.....	1.50
100 of charcoal at	2.10.....	2.10
Labor at 1.70 to	1.10.....	1.87
		5.47f.

1t. ore gives 180k. of matte.
Cost of the ore per ton is..... 0.985

No. 5.—*Cost of Roasting at Roraas.*

1.30 of wood at	1.00.....	1.30
Labor, 3.40 at	1.10.....	3.74
		5.04f.
Cost per ton of ore..... ..		1.51

No. 6.—*At Roraas in* 1856.

Quantity of matte roasted,	6580.80	
Weight of roasted ore,	6281.	
Wood consumed,	809.44 st.	
Wood at 6.93.....		1.016
Labor		3.486
		4.502f.

(4.) FUSION FOR BLACK COPPER.

No. 1.—*Details of Shaft Furnace at Atoida.*

Height	4.20
Diam. in direction of blast at bosh	2.00
Diam. perpendicular to " "	3.00
Height of bosh above hearth,	1.20
Diam. in direction of blast at tympe	0.75
Diam. perpendicular to " "	1.60
Diam. perpend. to blast at tuyeres,	0.60
Diam. in direction of " "	0.60
Width of hearth,	1.50
Depth of hearth,	0.20 to 0.25
Number of tuyeres,	2
Tuyeres above hearth,	0.45
Width of furnace at tuyeres,	60 × 60

No. 2—*Furnaces in* 1857.

Height,	5.05
Height of tuyeres,	0.60
Size of hearth at bottom,	0.70 × 0.60
" " tuyeres,	0.84 × 0.74
" at 1.78 above hearth,	1.34 × 0.74
" at throat,	0.74 × 0.44

No. 3—*General Composition of Matte.*

Cu	55. to 65.7%
Fe	15. " 20.
Zn	0.1 " 0.5
S	24. " 24.5

No. 4.—*Matte at Fahlun.*

Cu	57.5
Fe	17.1
Zn	00.7
S	24.1
	99.4

No. 5—*Composition of Scoria at Fahlun.*

		Oxygen.		Oxygen.
Si	27.4	14.	32.8	17.
Fe	64.8		62.5	
Ca	0.5		0.1	
Mg	2.3	17.3	1.6	15.9
Al	3.5		0.3	
Cu	1.0		Trace.	
	99.5		97.3	

No. 6.—*Composition of Loupe.*

Fe	65	40.
Cu	30	50.
Zn	1	00.1
S	2	7.
Scoria	1	00.2
	99	97.3

No. 7.—*Charge at Roraas.*

Charcoal	0.510c.m.
Roasted mattes	1.59.mq.
Quartz	0.16m.q.

No. 8.—*Charge at Atoida in* 1848.

Poor roasted mattes	84	100
Rich " "	16	
Scoriæ, 1st fusion		8
Crasses and debris		8
Quartz and feldspar		2 to 4

No. 9.—*Details of Working.*

At Atoida.

Furnace 4 to 5m. high.	
Amount of matte smelted in 24h.	5t.
Blk Cu. obtained	1 to 1.5t.
Rich matte "	250 to 300k.
Fuel consumed per ton of matte.	480k.

At Roraas.

Matte	100k.
Quartz	10k.
Amount of matte roasted	5t.
Blk. Cu. obtained	0.900t.
Fuel for 1t. of matte	0.487

No. 10.—*Cost at Roraas in* 1851.

Fuel, 4.87 at 3.30	16.071
Labor, 2d. at 1.45	2.90
Special labor	0.840
	19.811f.
1 ton of ore gives 300k. of matte.	
Cost per ton	5.94f.
Quantity of matte roasted	6580.80t.
Refining crasses	256.10
Blk. Cu. obtained	1313.76
Charcoal consumed	2142.c.m.

(5.) FINING THE BLACK COPPER.

No. 1.—*Dimensions of Fining Furnace.*

Charge, 360k.

Diameter,	0.60m. to 0.68m.
Depth,	0.20m. " 0.30m.
Angle of the tuyere,	10° " 20°
Eye of do.	0.025m." 0.04m.

Charge, 1200k. to 1400k.

Major axis	0.90m.
Minor axis,	0.80m.
Depth,	0.45m.
Angle of tuyere,	30° to 40°
Eye of do.	.05m. to .06m.
Time of operation,	8hrs. to 9hrs.

No. 2.—*Fining at Atoida.*

Amount treated	950k.	
Length operation	7h. to 8h.	
Loss	12% to 13%	
Charcoal, 0.530 at 33f.		17.49
Labor, 3d. at 1.50		4.50
		21.99

No. 3.—*At Roraas.*

Charge	360k.	
Length operation	$3\frac{1}{2}$h. to 4h.	
Loss	20%	
Charcoal, 0.750 at 33		24.75
Labor by contract		6.50
		31.25

No. 4.—*At Roraas in* 1851.

Quantity treated	1313.76
Weight fined copper	1058.13
Yield, leaving out crasses.	80.4%
Yield, with the crasses	86.09%
Fuel consumed	640.56c.m.

No. 5.—*Resumé at Roraas*, 1851.

Charcoal in all operations	1277.78st.
Quantity as per inventory, showing a loss of 16%	8568.00c.m.
Value of wood & charcoal	43166.39
Transportation to works	1779.07
Sundries paid at the works	14628.41
Materials	228.05
Labor	26283.88
Expense of construction	3458.80
Central office expenses	863.19
Value of ore	56298.24
Administration	16122.72
	162828.76f.
Or by m.q. of fined Cu	153.885

(6.) REFINING THE ROSETTE COPPER.

No. 1.—*Furnace.*

Diameter of the throat..	0.50 to 0.60
Depth " " ..	0.25 to 0.35
Charge	200t. to 300t.

No. 2.—*Details at Atoida.*

Fuel consumed, 750k. at 35.....	24.75
Labor, 2d. at 1.50.....	3.00
Total cost of refining,.....	27.75f.

(7.) EXPENSE OF SWEDISH METHOD.

No. 1.—*At Atoida.*

	Wood.	Charcoal.	Labor.
Roasting,	0.24	50	0.40
Fusion for matte,		350	1.00
Roasting matte,	0.27	336	0.30
Fusion for blk. Cu.		118	0.50
Fining,		42	0.12
	0.51k.	596k.	2.32d.

No. 2.—*At Roraas.*

	Wood.	Charcoal.	Labor.
Roasting,	0.21		0.40
Fusion for matte,		360	0.90
Roasting matte,	0.39		1.00
Fining for blk. Cu.		178	0.60
Fining,		54	0.20
	0.60k.	592k.	3.10d.

No. 3.—*Cost per Ton of Ore.*

Wood and charcoal.....	20.02
Transportation of ore.....	0.82
Labor, &c.....	9.70
Total.....	30.54
Construction	1.70
Superintendence	6.75
General expenses.....	7.84
Cost of ore.....	26.00
	72.83f.

WORKS FOR TREATING 10,000T. OF ORE.

No. 1.—*Ore and Roasting Heaps.*

50t. can be worked on a space $6 \times 6 = 36$
Space required for circulation, 64
100s.m.

3 operations a yr. can be counted on, so that each space roasts 150t.
67 spaces are required.
Space required for roasting 10,000t.
$67 \times 100 = 6{,}700$s.m.
Space required for the ore, 5,000s.m.

No. 2.—*Fusion for Bronze Matte.*

Each furnace smelts 10t. in 24h.
in 250d, 2500t.
No. of furnaces required..... 4

No. 3.—*Fusion for Black Copper.*

There are to be treated bronze matte 1800t
Rich slags from blk. Cu 200
2000
Each furnace smelts 4t. in 24h. and works 250d.
No. of furnaces required..... 2

No. 4.—*Fining and Refining Furnaces.*

The matte yields 20%
Blk. Cu. obtained ..... 400k.
In 7 to 8h. 950k. of blk. Cu. are fined.
No. of furnaces required..... 1

No. 5.—*Blast.*

Furnace for mattes 12c.m. per minute, $12 \times 4 = 48$s.m.
Furnace for Blk. Cu. 8c.m. per minute, $8 \times 2 = 16$s.m.
Fusion furnace 8c.m. per minute, $8 \times 1 = 8$s.m.
72s.m.
On account of loss, say, 80s.m.
Horse power required, 5 to 6

No. 6.—*Stalls.*

Each stall roasts 20t.a year.
No. required for 2000k. of matte, 100, say 120
Under 6 sheds 20×10, 1200s.m.
Double space for circulation, 2400s.m.

No. 7.—*Charcoal Sheds.*

8 charcoal sheds, 10×50 or 4000s.m.
Double space for circulation, 8000s.m.

No. 8.—*Works.*

Works require a building 50×12
Double space for circulation, 1200s.m.

No. 9.—Total Space Required.

Ore heaps	5000s.m.
Roasting heaps	6700
Roasting stalls	2400
Charcoal sheds	8000
Works	1200
Scoria heaps fr. 30 to 40 yrs.,	30,000
	53,300

Or, 5 to 6 Hectares.

TREATMENT AT BOSTON WORKS.

1854.

No. 1.—Expenses to Roast 1t. of Ore.

Wood, 0.0768c.m.	0.265
Labor, 0.15d.	0.800
	1.065f.

No. 2.—Dimensions of Shaft Furnace.

Section at tuyeres	0.78 × 0.62
Height	2.75 to 3
Tuyere to throat	1.40
Opening for charging	1.00
Breast below front hearth	.15
Depth of hearth below breast	.20
Front hearth extends	.15
Depth of " below tuyeres.	.35
Diameter of tuyeres	.03 to .05
Thickness of fire-brick	.35
" of breast	1 brick.
" of common brick	.45
Space between common & refractory brick	.04 to .05

No. 3.—Composition of Brasque of Hearth, (Shaft Furnace.)

6 clay,
18 coke dust, } or 24 coke dust alone.
6 charcoal, }

No. 4.—Charge of Furnace.

Roasted ores, 18 to 20%Cu	1000
Oxydes not roasted	33
Debris of furnaces, and clay from bottom of roasting heaps.	50
Scoriæ from blk. Cu	330
Oyster shells	100
	1513

Proportion of mattes,	56%
Yield "	34 to 45%
Fuel for 1t. of ore,	194k.

Average campaign is 15 days.

No. 5.—Details for Campaign of 15 days.

Ore treated, 90 tons.

Lighting furnaces	30.
Anthracite, 16t. at 42	672.
Brasque for reception basins	60.
1 founder, 60d. at 7	420.
1 assistant, 5d. " 5.25	26.25
Repairs	60.75
Cost of treating 90t.	1269f.
Cost for 1t.	14.10f.
Mattes produced (of 45%Cu)	25t.
Blk. Cu " (of 85%Cu)	5.

No. 6.—Costs for Roasting in Stalls.

Wood for lighting, 0.192c.m.	3.312
Labor, 2.25d at 5.25	11.800
Charcoal for lighting	0.500
Cost of 5t. of mattes	15.612
" 1t. "	3.122

For 1t. of Ore.

Wood, 0.052c.m.	0.183
Labor, 0.125d	0.656
	0.839f.

No. 7.—Fusion for Blk. Cu.

Length of campaign, 12 to 15d.
Quantity treated in 24hrs., 8 to 9t.

No. 8.—Charge.

Roasted mattes	1000
Oxydes of Cu	140
Rich roasted mattes	60
	1200
Rich scoria	80
Silicious "	450
Debris of furnaces	50

No. 9.—Quantity Treated.

Length of campaign	15d.
Mattes treated	180t.
Rich ores	13
Scoria	85
In 2 furnaces	278t.

No. 10.—*Cost of Fusion.*

Charcoal for 2 furn.,	1t. at	50	50
Anthracite,	30t. "	42	...1260
Founders,	120d "	7	840
Common labor,	30d. "	5.25	....157.50
Repairs			.....121.50
Cost of 278t. in 2 furnaees			....2429.00

No. 11.—*Amount of Mattes Produced.*

Mattes contain 50%Cu.

13t. of ore of 20%,	13 × .20 ÷ 50 = 5.2
85t. of scoria of 10%	85 × .10 ÷ 50 = 17.
278t. of matte	180.
Mattes produeed	202.2t.

No. 12.—*Expense for* 1*t. of Matte.*

Charcoal,	0.004t	at	50..	0.200
Anthracite,	0.148	"	42..	0.222
Founders	0.59d.	"	7..	4.130
Common labor,	0.15d.	"	5.25..	0.790
Repairs				600
For 1t. of matte				11.942

No. 13.—*Expense for* 1*t. of Ore.*

Anthracite,	0.045	at	42	....1.890
Charcoal,	0.001	"	50	....0.050
Common labor,	0.045d	"	5.25	....0.236
Founders,	0.182d	"	7.	....1.274
Repairs				.....0.200
				3.650

No. 14.—*Cost for* 1*t. of Ore, Converted into Blk. Cu.*

Wood,	0.052t	at	3.45	.... 0.448
Chareoal,	0.0065t	"	50	.... 0.325
Anthraeite,	0.222t	"	42	.... 9.324

Labor.

1st roasting,	0.15	1.222d.	7.693
1st fusion,	0.72		
2d roasting,	0.125		
2d fusion,	0.227		
Repairs			0.871
Cost of blk. Cu. for 1t. of ore			18.660

No. 15.—*Fining of Blk. Cu.*

Dimensions of Furnace.

Length of hearth	3.50m.
Width "	2.50
Length of fireplaee	1.37
Width "	1.32

No. 16.—*Cost of Fining.*

Labor, 14d. at 7	98.00
Coal, 7t. at 42.50	297.50
Wood & eharcoal, 0.185t	34.00
Lead (for Sb.) 0.160t at 5.50	88.00
Repairs	14.00
Cost of 2 furnaees, 1d	531.50

No. 17.—*Expenses for Refining* 1*t. of Blk. Cu.*

Labor,	0.875d	6.125
Coal,	0.437t	19.080
Wood & chareoal,	0.053t	2.122
Pb,	0.010t	5.500
Repairs,		0.875
Cost of 1t. of merchant. Cu.		33.702
Cost by ton of ore		4.776

No. 18.—*Treatment of* 1*t. of Ore.*

Treatment	18.660
Fining	4.776
Speeial expenses	23.436
General "	20.000
Cost of treatment of 1t. of ore.	43.436f.

Price of ore is variable.

Ores yield 20% of Cu.	
Value of Cu. per ton	2500f.
1t. ore yields 2500 × 20%	500

IMPURE ORES.

WORKS AT ALTENAU AND LAUTENTHAL IN THE HARTZ MOUNTAINS.

No. 1.—*Roasting Ores as Sweden.*

Ores contain 17 to 18% of Cu.
Piles contain 50 to 100t.
Fuel used per ton of ore, 0.26st.
Time, 3 months.

No. 2.—*Fusion for Mattes in a Shaft Furnace.*

Charge.

Roasted ores	1000t.
Scoria of fusion for concentration and blk. Cu.	950k.
Quantity fused in 24hrs	3 to 3½t.
Fuel (gas coke) for 1t. of ore.	501k.
Mattes 30 to 35%	675k.

No. 3.—*Roasting in Stalls.*

Number of fires	3
For ton of matte, wood	0.250st.
Labor	0.12d.

No. 4.—*Fusion for Concentration.*

Charge.

Roasted matte	1000k.
Scoria	828
Quantity smelted in 24 hrs.	4t.
Labor for 1 ton of matte	1d.
Charcoal	690k.
Product for 1t. of roasted matte, at 40 to 45% and Scorias containing 1½% of Cu. which are used in No. 2.	736k.

No. 5.—*Roasting in* 5 *or* 6 *Fires.*

No. 6.—*Fusion for Blk. Cu. and Thin Mattes.*

2d mattes roasted	1000
Scoria of fusion No. 2	945

Per ton of concentrated matte.

1st Blk. Cu. (very impure.)	128
1st thin matte, 65% of Cu	450
Scoria 1.5% Cu	1377
Charcoal	660k.
Labor	1.18d.

No. 7.—*Roasting* 1*st Thin Mattes.*

For 1t. of thin mattes.

Number of fires	7 to 8.
Wood	0.60st.
Labor	0.27 d.

No. 8.—2*d Fusion for Blk. Cu. and Thin Mattes.*

2d Blk. Cu	327k.
2d thin mattes 69% Cu	400k.
Scoria with 3% Cu	1200k.
Fuel	655k.
Labor	0.93d.

No. 9.—*Roasting* 2*d Thin Mattes.*

Number of fires	9
For ton of mattes, wood	1.6st.
For ton of mattes, labor	0.50

No. 10.—3*d Fusion for Black Copper and Thin Mattes.*

3d mattes with 73% of Cu.	265
3d blk. Cu	547
Scoria with 3% of Cu	1100 to 1200
Charcoal	862k.
Labor	1d.

No. 11.—*Purification of the Blk. Cu.*

The 497 of mattes give impure blk. Cu. 64.

For 1t. of blk. Cu.

Wood	4st.
Charcoal	37k.
Labor	3.50d.

Yield of the fusion.

Copper	880k.
Scoria of 4%	130k.

No. 12.—*Fining in Low Hearth.*

Charge	2t.

By ton of blk. Cu.

Charcoal	1.016k.
Labor	3.17d.
Rosette copper	890k.
Scoria 22 to 30% of Pb. & 12 to 14% of Cu	220k.

No. 13.—*Refining.*

No. 14.—*Total Expense.*

		Weight.	Coke.	Wood.	Charcoal.	Labor.
1.	Roasting	1000		0.026		0.15
2.	1st fusion for mattes	1000	501k.		12t.	1.67
3.	Roasting mattes	675		0.170		0.08
4.	Fusion for concentration	675			466	0.67
5.	Roasting of No. 4	497		0.250		0.10
6.	1st Fusion for blk. Cu thin mattes	497			330	0.59
7.	Roasting 1st thin matte	224		0.134		0.062
8.	2d fusion for blk. Cu. & thin mattes.	224			147	0.210
9.	Roasting the 2d thin matte	90		0.114		0.045
10.	3d fusion for blk. Cu. & thin mattes.	90			78	0.090
11.	Purification of blk. Cu	64		0.256	2	0.224
12.	Fining.					
	Blk. Cu. from No. 1 56					
	2d blk. Cu. 51					
	3d " 49	175			177	0.554
	Blk. Cu. for 3d mattes....19					
	Rosette Cu. produced 155k.		501k.	0.980st.	1.212k.	4.443d.

TREATMENT AT MANSFELD.

Treatment.

Quartzose ore at Sangerhausen.
Schistose ore at Mansfeld and Eisleben.
Ores with Blende and Galena at Kupferkammerhütte.

Treatment at Sangerhausen.

No. 1.—*Roasting in* 1850.

Height of the pile	2.30m.
Length variable.	
Quantity of ore treated	2400t.
" calcined in 10 weeks	150t.
Labor required for treatment	2904d.
Length of campaign	290d.

No. 2.—*Cost of* 9 *Piles, in* 1850.

Wood	9.60t.
Labor by ton,	4.80d.
Labor 0.17 at 0.20	0.17
Wood 0.004t. at 15	0.06
Cost of calcining 1t	0.23f.

No. 3.—*Fusion for Mattes.*

Charge.

Quartzose ores not roasted	33.34
Calcareous " "	8.33
Roasted Schistose ores	58.33
Scoria	31.33
Fluor	38.38

No. 4.—*Quantity Treated in* 24*h.*

Charge containing 8.25t. of ore.	14t.
Fuel used	2.90

For 1 Ton of Ore.

Labor, 1.21d. at 0.20	2.42
Charcoal, 0.35t. at 41.60	14.56
Fluor, 0.35t. at 4.10	4.93
Blast and repairs	0.41
	22.33

Fuel $\frac{1}{3}$ charcoal & $\frac{2}{3}$ coke.
Pressure of the blast, 0.03m. to 0.04m. Hg
Heat " " 170° to 180°

No. 5.—*Labor Required.*

At the throat, 1 laborer and 1 aid.
" bottom, 1 founder & 1 laborer.

Treatment at Mansfeld and Eisleben.

No. 6.—*Fusion for Matte in a Shaft Furnace.*

Charge.

Roasted ore	86.66
Fluor	6.66
Scoria	6.68
	100.00

In 24 hours.

Charge containing 12t. of ore.	14t.
Yield of the matte, 11% of ore.	
Matte contains 45% of Cu. & 300g. Ag. per 100k.	

No. 7.—Expenses of Operations.

Charcoal,	0.07	at 41.60	2.912
Coke,	0.11	at 58.	6.380
Labor,	0.833	at 2.	1.666
Fluor,	0.075	at 14.10	1.050
Repairs			0.292
			12.300

Treatment at Kupferhammerhütte.

No. 8.—Fusion for Mattes.

Charge.

Roasted ores, from 100k. of ore.	86.66
Fluor,	4.60
Scoria,	8.74
	100.00

Ores treated in 24h.			9.60t.
Labor,	0.04		2.02
Coke,	0.12	at 58.	6.96
Fluor,	0.046	" 14.10	0.648
Repairs			0.362
			10.05

From 7,640t. of ore, 860t. of matte or 11% obtained.

No. 9.—Roasting Stalls.

Height	2m.
Width	2m.
Depth	2.50
Time for 1st fire	12d.
" for 2d fire	12 to 15d.

No. 10.—Fusion for Mattes.

Length of campaign,	2.5 months.
Amount of ore treated,	7000t.
Matte obtained in 2 campaigns,	860t.

No. 11.—Roasting 1t. of Matte.

Charcoal,	0.016	at 41.60	0.665
Wood and brush,	0.05	at 15.5	0.775
Labor			0.56
			2.00

By Ton of Ore.

Charcoal,	0.0017	0.070
Wood and brush,	0.0053	0.082
Labor,	0.03	0.060
		0.212

No. 12. – Cost of 2d Fusion for 1t. of Roasted Matte.

Labor,	1.48		2.96
Coke,	0.278t		16.12
Repairs			0.74
			19.82

Cost by Ton of Ore.

Labor,	0.155	0.310
Coke,	0.029	1.682
Repairs		0.075
		2.067

Quantity of mattes produced	5.320t.
" of scoria "	1.350t.

No. 13.—Cost of all the Operations for One Year.

Labor,	1.365	at 2	2.610
Coke,	0.149	at 58	8.642
Charcoal (roasting)	0.0017	at 41.60	0.070
Wood and faggots,	0.0093		0.144
Fluor,	0.046	at 14.10	0.648
Repairs			0.437
Expenses for 1t. of ore			12.551

TREATMENT AT AGORDO.

Treatment.

Dry way.

1. Fusion for mattes in a shaft Furnace.
2. Roasting the mattes in stalls.
3. Fusion in a shaft furnace.

Products.

(*a*) Rich scoria.
(*b*) Rich matte.
(*c*) Blk. Cu.

4. Fining the blk. Cu. in a low hearth.

Wet way.

1. Roasting in piles.
2. Lixiviation.
3. Cementation.
4. Crystalization.

No. 1.—Prices of Fuel at Agordo.

Wood,	10.52
Charcoal,	57.50
Peat,	11.20
Labor,	1.20

No. 2.—Dimensions, &c., of Piles at Agordo.

Quantity of ore	200t.
Number of piles	60 to 65
Wood used	5.20c.m.
Width of pile	6.00
Length "	variable.
Height "	2.50
Width of upper part	3m.

No. 3.—Details of Styrian Kiln.

Length	20.0
Interior width	7.00
Height	3.00
Thickness of walls	0.75

No. 4.—Cost of Roasting.

Ore treated	150,000t.
Number of piles	63
Men for making pile	7
" taking the sulphur	1
Wood, 0.026c.m. at 4.02	0.104
Labor 0.147d. at 1.30	0.191
Cost of roasting 1t.	0.295

Large pieces.

No. of children for breaking	120
Pay of children per day	0.50
100k. of ore give 13.26k. concentrated ore	
Labor, 2.491d. at 0.50	1.245
Cost of breaking for 1t. of ore.	1.245

No. 5.—Details for Sulphur.

Two men occupied at 6.35 per ton of S.
Amount produced, 45 to 50t.

1853. 50t. of S at 187

Wood, 0.712c.m. at 4.02	2.886
Labor, 3.40 at 1.87	6.358
Cost of 1t. of S	9.244

No. 6.—Details of Lixiviation.

Ore roasted	15,000t.
Roasted earth, resulting	13,700t.
Ore passed in 3 lixiviations	40,000t.
Water at 25° to 27° produced.	3,000c.m.
Number men for 13,700t. of roasted ore or 40,000t. of material handled,	30
Labor for 1t. of ore, 1.34d.	1.608

No. 7.—Details for 1853.

Quantity of liquid treated			3000c.m.
Cast iron of 72t. at 224f.			16128.
Wood	981c.m.	4.02	3943.62
Peat,	482c.m.	2.24	1079.68
Charcoal,	643c.m.	9.16	5889.88
Labor,	2400d.	1.20	2880.
Repairs, brooms, &c			400.
			30,321.18

No. 8.—Amount Produced.

Rich cement at 50 to 60%	61.494t.
Poor " " 10%	15.984t.
	77.478t.

Or at a mean yield of 50% 38.739t. of Cu.
Cost of ton 2.0214

No. 9.—Crystalization Tanks.

Length	3 to 3.50
Width	2m.
Depth	0.50

No. 10.—Analysis of the Crystals.

Ḟe S̈	49.73
F̈e S̈	3.20
Żn S̈	4.55
Ḣ	42.52
	100.00

Pure crystals with 7% of Ḣ have 55% of ḞeS̈

No. 11.—Cost of Crystalization.

Number of men	2
Labor	1.10
Packing and freight	3.60
Cost of 1t. of crystals	4.70

(1.) Fusion.

No. 12.—*Charge.*

Concentrated ores	60.198
Rich ores	11.445
Cement	6.919
Crasses	4.770
Scoria	15.503
Red sandstone	14.540
Charge in 24h	16t.

No. 13.—*Treatment of* 1600*t.*

Rich scoria and ores	1600t.
Number of campaigns	9
Length of campaigns	20d.
Charcoal	621t.
Red sandstone	270t.
Labor	1440d.

No. 14.—*For One Campaign.*

Ore treated in one campaign, 1,777.778t.

Charcoal,	69t.	at 57.25	3950.25
Labor,	160d.	" 1.50	240.00
Red sandstone,	30t.	" 15	450.00
Repairs			500.00
Cost of one campaign			5140.25f.
Cost for 1t. of ore			3.061f.

No. 15.—*Quantity Treated.*

Concentrated ores	257t.
Rich ores	19.60t.
Mattes produced (pr. campaign)	96t.
" " (pr. year)	896t.
Yield of mattes	24 to 25%

No. 16.—*Composition of the Matte.*

Cu	24.10
Fe & Zn	49.60
S	26.30
	100.00

(2.) Roasting.

No. 17.—*Roasting Stalls.*

Number of fires	5
Length of stalls	3.60m.
Width "	2.60m.
Height "	1.80m.
No. of stalls arranged in 2 rows.	24
Charge in each	8t.
Time required	14 to 15d.

No. 18.—*Expenses for* 1 *Year.*

Wood	264t.
Peat	113t.
Charcoal	96t.
Labor, at 1.10	2952d.

For 1t. of matte.

Wood,	0.220	at 10.52	2.315
Peat,	0.094	" 11.20	0.828
Charcoal,	0.080	" 57.25	4.580
Labor,	2.46d.	" 1.10	2.706
Cost for 1t. of ore			0.852
			10.429f.

(3.) Fusion for Black Copper.

No. 19.—*Charge.*

Roasted mattes	95.146
Refining crasses	2.257
Scoria	21.000
Red sandstone	2.000

No. 20.—*Details for* 1853.

Length of campaign	10d.
Amount fused	60 to 80t.
Quantity in 24h	7 to 8t.
Quantity treated	1200t.
Number of campaigns	16
Mean of each	75t.

No. 21.—*Expense of Treatment.*

Charcoal,	2368t.	at 57.25	13.5568
Labor,	80d.	at 1.50	120.00
Repairs			400.00
			1975.68f.
For 1t. of matte			25.10
" " ore			2.00

Result.

Blk. Cu. at 94%	11.85t.
Matte at 60%	11.55t.
	23.43t.

(4.) Fining and Refining.

No. 22.—*Expense.*

Labor,	5d. at	2.00	10.00
Chareoal,	1.30 "	55.25	74.75
Repairs			25.00
			119.45f.

For 1t. of Cu	59.73f.
" " ore	1.162f.
Amount of rosette Cu. in a year	240t.

No. 23.—*Expense for* 1*t. of Ore.*

Labor,	3.2203d	2.931
Wood,	0.0526t	0.552
Peat,	0.0141	0.1578
Charcoal,	0.0795	4.5500
Cast iron,	0.048	1.0752
Flux, repairs, &c		1.2885
		10.5545f.

ENGLISH METHOD

PURE ORES.

Treatment.

1. Roasting the ore.
2. Fusion for bronze mattes.
3. Roasting the bronze mattes.
4. Fusion for white mattes.
5. Roasting the white mattes, & fusion for blk. Cu.
6. Fining and refining.

No. 1.—*Assay of the Ore.*

Small.	Medium.	Large.
a b	a b c	a b e d
c d	d e f	e f g h
a b	a	
c d		d taken away.

No. 2.—*Moisture in Ores.*

	Max.	Min.
Rich ore,	15%	6%
Cement from Cuba,	25%	
Mattes Chili,	3 to 11%	$\frac{2}{4}$%
Ordinary English,	5 to 9%	1%

(1.) Roasting the Ore.

No. 3.—*English Furnace for Roasting Cu. Ores.*

Furnace with 2 hearths.

Length less the fireplace	9.15
Width	4.20
No. brieks with chimney	50000
Labor of mason	156d.
Boy to attend him	156d.
Laborer	48d.
Construetion takes	20d.
Iron-bracing { blacksmith	7d.
Iron-bracing { aid	7d.

No. 4.—*Large Reverberatory Furnaces.*

Length	6.10 to 6.86
Width	4.85 to 4.57
Fireplaee, length	1.90
" width	1.20 to 2.68
Height at fireplaee	1.80
" ehimney	1.37
Length in the middle	4.27 to 5.25
Width " "	3.35 to 3.65
Thickness of sides	0.60
" " at fireplaee.	0.63
" of end "	0.23
No. of fire-bricks	8500
Ordinary "	3500
" red bricks	3000

Labor for Construetion.

Mason	60d.
Aid	60d.
Laborer	60d.
Furnaee ean be built in	10d.

Relation of the Parts.

Surfaee of fireplaee	1.08 to 1
" hearth	16 to 15
Flues	0.24 to $\frac{1}{4}$ or $\frac{1}{5}$
Volume of laboratory	800 to 7.5

No. 5.—*Working of the Furnace.*

Charge in double furnace	4t.
" single "	3t.
Charge remains on upper hearth	4h.
" lower "	6h.
Coal per week	7t.
Charges of ore per week	24
Weight of ore	90 to 100k.
No. of weeks' work in a year	48 to 50
No. of men, day 4, night, 4.	8d.

No. 6.—Composition of the Ore.

	Ore 10%	Ore 8%
Cu	10	8
S	15 to 20	23
$\ddot{S}i$	45 to 55	45
Fe	20 to 25	24

No. 7.—Results of Roasting.

Ore.		Roasted Ore.	
CuS	Cu 8	Cu 8	
	S 2	S 2	
		S 10 lost.	
Fe^2S^3	S 21	O 5.4	$\ddot{F}e$
	Fe 24	Fe 12	
		S 11	Fe^2S^3
		Fe 2	
	$\ddot{S}i$ 45	$\ddot{S}i$ 45	

No. 8.—Expense of Roasting.

Transportation of ore.....	0.230
Coal, 0.123t....	0.707
Labor, 0.35d	0.927
Repairs.....	0.158
	2.022

(2.) Fusion for Bronze Mattes.

No. 9.—Furnace for Fusion for Bronze Mattes.

		Ratio.
Fireplace.....	1.96	1
Hearth.....	9.0	4.5
Flue.....	0.12	$\frac{1}{16}$
Chimney.....	0.42	$\frac{1}{4}$ to $\frac{1}{5}$
Volume of laboratory....	4.09	2.5
Fuel used, per h.....	140	
	Large furnace.	Ratio.
Fireplace.....	1.7 to 2	1
Hearth	16.25	9 to 8

Fuel, 170k. pr. h. or 25 to 30t. pr. week.

No. 10.—Sand used for Hearth.

	Blown.	Refractory.		
		(1)	(2)	(3)
$\ddot{S}i$	86.	92	92	93
$\dot{F}e$	1.2	11	8	7
$\dot{C}a$	5.7			
$\dot{M}g$	.8			
$\ddot{A}l$	1.6			
$\ddot{C}+\dot{H}$	4.5			

No. 11.—Brick for Furnace.

Best fire-brick.....	8104
Ordinary brick.....13271	
	21,375

No. 12.—Charge for Fusion for Bronze Mattes.

		Large furnace.
Roasted ores,	0.900	1.800
Unroasted ores,	0.100	1.300
Fluor,	0.050	
Scoria of same operation,	0.070	.400
Scoria, 4% 0.107 / 5 to 7% 0.064 / 9% 0.009	.180	
	1.300t.	3.500t.

Mixture of fuel is $\frac{1}{3}$ bituminous, $\frac{2}{3}$ dry coal.

Thickness of fuel on grate... .30 to .40

Furnace worked by 2 men.

2 shifts per 24h.

No. 13.—Composition of Matte.

	Matte.	Matte.	Chalcopyrite.
Cu	30 to 36	33.7	34.6
Fe	35 " 30	33.6	30.5
S	30 " 30	29.2	34.9
Ni & Co		1.	
Sn Sb As		1.	
Scoria,	1 " 2	1.1	
		99.6	100

No. 14.—Roasted Ores.

Cu	10.25 to 11.
Fe	34 " 39
S	7.5 " 10.5
$\ddot{S}i$	55 " 65

Product.

Bronze Mattes.		Scorias.	
Cu	10.25 to 11.	Fe	24 to 27
Fe	10.25 " 15.	$\ddot{S}i$	55 to 65
S	10.2 " 7		

Scoria generally.

$\dot{F}e$ 34.62 / $\ddot{S}i$ 65.38 $\}$ $\dot{R}\ddot{S}i$

No. 15.—*Composition of Scoria.*

S̈i	30.00
Quartz,	30.50
Ḟe	28.50
Ä̇l	2.90
Ṁg	0.60
Ni & Co	1.40
Ċa	2.00
CaFl	2.10
Cu	0.50
Fe	0.90
S	.60
	100.00

No. 16.—*Cost of Treatment for* 1*t. of Ore.*

Coal,	0.78 at 6.30..	4.95
Labor,	0.64d. " 3.60..	2.31
Fluor,	0.051 ..	0.64
Sand and bricks, Repairs,	.....	0.55
		8.45f.

(3.) Roasting the Bronze Matte.

No. 17.—*Expense of Roasting.*

Fuel used in a week.....	7t.
No. of men, (day 2, night 2).	4d.
Pay of men per week.....	23 to 25f.
No. of charges "	6

For 1t. of Bronze Mattes.

Coal, 0.410.....	2.38
Labor, 0.67.....	2.49
Repairs.....	0.13
	5.00

No. 18.—*Composition of the Roasted Matte.*

Cu	33
Fe	33
S	33

(4.) Fusion for White Mattes.

No. 19.—*Charge.*

	1	2	3
Roasted matte.....	2400	2300	2400
Rich unroasted ore.	2400	2400	2000
Refining scorias....	400	500	800
	5200	5200	5200

No. 20.—*Composition of the Scorias.*

S̈i	35
Ḟe	58
Ċu	1
Other bases,	6
	100

No. 21.—*White Mattes.*

	Poor.		Rich.	
Cu	65	72	70	83
S	23	21	30	17
Fe	9	5		
Scoria,	3	2		
	100	100	100	100

No. 22.—*Expense of Fusion.*

Coal, .95.....	5.89
Labor, .65.....	3.55
General expenses.....	0.79
	10.23f.

Charge.

Roasted mattes.....	0.697
Oxydes.....	0.303
	1.000

(5.) Roasting the White Matte.

No. 23.—*Dimensions of the Furnace.*

Width of fireplace.....	1.30
Length of "	1.40
Greater axis of hearth.....	4.30
Smaller " "	3.00
Length of bridge.....	2.00
Width of hearth at flue.....	0.90
Height of chimney.....	18.00
Width of working door.....	0.33
Height of " "	0.25
Width of charging "	0.50
Height of " "	0.35
Taphole.....	0.11 × 0.11

1.707t.

No. 24.—Relation of the Parts.

Surface of fireplace,	1.82.....	1
" of hearth,	8 to 9. ...	4.5
Section of flue,	0.12.....	.67
" of chimney,	0.42.....	.22
olume of laboratory,	4 to 5c.m...	2to2½

No. 25.—Composition of the Blk. Copper.

Cu	98....	99.0
Fe	1....	0.5
S	1....	0.3
Scoria,	1....	0.5

No. 26.—Expense of the Operation.

Coal,	0.6t.....	3.72
Labor,	0.4d	1.75
Repairs.....		0.37
		5.84

(6.) Fining and Refining.

No. 27.—Dimensions of the Furnace.

Length of fireplace.....	1.40
Width of "	1.30
Length of hearth.....	3.50
Width of hearth at the middle...	2.50
" " at the bridge....	2.00
" " at the flue.....	0.66
Height of arch " "	0.60

No. 28.—Relation of the Parts.

Fireplace.....	1
Hearth	4
Flue.....	0.67
Chimney.....	0.22
Volume of laboratory.....	1 to 2.5

No. 29.—Select Copper.

Cu	99.80 to 99.85
Fe	0.20 to 0.15
No Pb or Sb.	Traces of O and Ag.

No. 30.— Unsaleable Copper.

Cu.....	99.85
Fe.....	0.10
Sb.....	.01

No. 31.—Rosette or Cake Copper.

Cu	99.60.....	99.70
Fe	.10.....	.15
Pb	.15.....	.10
Sb	.06.....	.04
Ag	none.	none
	99.91	99.99

No. 32.—

Coal,	0.427.....	2.66
Labor,	1.	3.14
Anthracite,	0.060.....	0.90
Wood,	23k.....	0.87
Repairs.....		0.86
		8.43

IMPURE ORES.

Treatment.

1. Roasting ore.
2. Fusion for bronze mattes.
3. Roasting the bronze mattes.
4. Fusion for white mattes.
5. Fusion for blue mattes.
6. Fusion of scorias for red or white mattes.
7. Roasting the blue mattes and fusion for extra white mattes.
8. Roasting the mattes Nos. 6. & 7, and fusion for purple metal.
9. Roasting mattes Nos. 4, 7 & 8, and fusion for blk. Cu.
10. Fining and refining.

Nos. 1, 2, 3 & 4 are the same in both processes.

(5.) Fusion for Blue Mattes.

No. 1.—Charge.

Roasted bronze mattes.....	1.392
Sulph. & carbonate ores 15 to 25%	0.408
Sand, scorias, debris of furnaces.	0.203
	2.003

No. 2.—Details of the Fusion.

Per 24 hrs., 2 men and 1 child.

No. of charges per week.....	22

For 1t. of Charge.

Labor, 0.338 at 4.85.....	1.639
Fuel, 0.706 at 6.17.....	4.356
Repairs, tools, &c.....	0.585
	6.580f.

For 1t. of Ore.

Labor, 0.1552	0.7524
Fuel, 0.2824	1.7424
Repairs, tools, &c	0.2340
	2.7294f.

100t. ore yield 25t. matte.

No. 3.—*Composition of Scoria & Mattes.*

Scoria.	Matte.	
Si 33 to 35	Cu	56.7
Fe 55	Fe	16.3
	S	22.
	Ni & Co	1.6
	Sn.As.Sb.	1.2
	Scoria,	0.5
		98.3

(6.) Fusion of Scorias for Red or White Mattes.

No. 4.—*Charge.*

Scorias 4, 7 & 8, of 10 to 12%..	1.718t.
Quartz. sulphurous ore, 10 to 15%.	.166
Scales and sweepings	.110
Anthracite	.099
Silica, taken from the hearth during the operation	0.096

No. 5.—*Details of the Operation.*

Time for charge, 2t	6h.
No. of operations per week	22
Furn. lasts without repairing hearth	2m.
Flues last " "	2m.
Furnace lasts	18 to 24m.

No. 6.—*Expense of the Fusion.*

For 1t. of Charge.

Labor, 0.392 at 4.40	1.725
Fuel, 0.566t. at 6.17	3.492
Repairs, tools, &c	0.630
	5.847f.

Cost for 1t. of Ore.

If 1t. scoria = 0.20t. of ore.

Labor, 0.0784	0.345
Fuel, 0.1132	0.698
Repairs, &c	0.126
Cost per ton of ore	1.169f.

No. 7.—*Analysis of the Products.*

	Mattes. Rich.	Poor.
Cu	74.6	62.1
Fe	3.1	12.1
Sn	0.3	1.8
S	20.2	22.8
Scoria,	1.1	.7
	99.3	99.5
	Black Copper.	Alloy.
Cu	86.0	66.2
Fe.Ni Co	3.2	28.4
Sn Sb	0.7	2.7
As	1.8	2.0
S	6.9	Trace.
	98.6	99.3

(7.) Roasting the Blue Mattes & Fusion for Extra White Mattes.

No. 8.—*Expense of the Operation.*

Labor, 0.880d. at 2.68	2.165
Fuel, 0.820t. at 6.15	5.048
Repairs, tools, &c	0.834
	8.047

For 1t. of Charge.

If 100t. of ore yield 40t. of matte.

Labor, 0.161	0.433
Fuel, 0.144	1.008
Repairs, tools, &c	0.167
	1.608

No. 9.—*Extra White Mattes.*

Cu	77.5
Fe	2.2
S	20.1
Sb & As	Trace.
	99.8

(8.) Roasting the Mattes Nos. 6 and 7 and Fusion for Purple Metal.

No. 10.—*Expense of the Operation.*

For 1t. of Mattes.

Labor, 0.507 at 2.95	1.495
Fuel, 0.372 at 6.15	2.288
Sand, brick, repairs, &c	0.491
	4.274f.

For 1t. of Ore.

If 100t. of ore produce 12t. of mattes.

Labor,	0.061	0.179
Fuel,	0.045	0.276
Sand, repairs, &c		0.059
		0.514

No. 11.—*Analysis of the Products.*

Brute Copper.

	Kaofjord.	Swansea.
Cu	97.	92.5
Ni	1.6	
Fe	0.1	4.8
S	1.3	1.6
As & Sb		0.6
	100.0	99.5

Red Mattes.

	Kaofjord.	Swansea.
Cu	80.00	81.1
Ni & Co	0.50	
Fe	0.50	0.2
S	17.00	18.5
Seoria,	2.	
	100.	99.8

RESUME.

No. 1.—*General Details for each Operation.*

For 1t. of Ore treated Ordinary Method.

1. Quantity roasted.....790k.
   Quartz used in No. 2..... 88k.
   Rich ores in No. 4.....122k.
   1000k.

2.3. Charge..... 878k.
   Yield, 32% (878 × 0.35)..... 281
   Yield of matte..... 42%

4. Charge ....403k.
   Matte 200
   Yield of matte..... 70%

5. Charge .....200k.
   Yield, 60%.....120k.
   Amount Fe..... 1%

6. Charge .....120k.
   Yield.....114

No. 2.—*Details for all the Operations.*

	Weight of Charge.	Coal. Wt.	Coal. Price.	Labor. Days.	Labor. Cost.	Repairs. Cost.	Flux. Wt.	Flux. Cost.	Wood. Wt.	Wood. Cost.
1. Roasting.....	790	97	0.55	0.35	0.92	0.15				
2. Fusion { Ore, 88 / Bronze mattes, 790	878	680	4.31	0.56	2.03	0.48	44	0.56		
3. Roasting	281	115	0.67	0.19	0.70	0.04				
4. Fusion { Mattes, 281 / Ores, 122	403	380	2.36	0.26	1.42	0.32				
5. Fusion for blk. or blister Cu.	120	120	0.74	0.08	0.35	0.07				
6. Fining & refining.....	120	006	0.43	0.12	0.38	0.10			3k.	0.16
Copper produced.....1142	1452	9.06	1.86	5.80	1.16	44	0.56	3k.	0.16	

No. 3.—*Cost of* 1*t. of Merchant Copper.*

Coal,	12.13.....	79.46
Labor,	13.68.....	50.87
Repairs, bricks, &c.	610k.....	10.77
Flux,	0.39.....	4.91
Wood,	0.025.....	0.88
		146.89

For 1 Ton of Ore.

Special expenses.....	16.68
General ex. interest on capital,&c.	30.00
	46.68f.
Capital required per 1t. of Cu. a a year.....	250f.
Rolling capital.....	1000f.
	1250f.

CALCULATION FOR THE CONSTRUCTION OF WORKS FOR THE ENGLISH METHOD.

No. 1.—

Legal interest in England	3%
Sinking fund	2%
	5%
Capital for 1t. of ore	250f.
250 × 0.114 (Cu. in 1t. of ore) =	28.5
28.5 at 5% = (1)	1.42
Rolling capital for 1t. Cu	1000
Interest on account risk	4%
Capital for 1t. of ore 1000 × 0.114	114
Interest on 114 at 4% (2)	5.76
Other general expenses (3)	5.32
Discounts added for time	3%
Commission	2%
	5%
If Cu. is worth 2500, 5% =	125
125 × 0.114 is for the ton of ore (4)	14.25

Resumé.

Interest on capital at 5%	(1)	1.42
Interest on rolling capital 4%	(2)	5.76
Other general expenses,	(3)	5.32
Total general expenses,		12.50f.

Commission & discount for time (4)	14.25
Freight on ore	32.00
Profit of 5%	1.25
	60.00
Oftener counted	65.00

No. 2.—*Furnaces Required for Treating* 47,000*t. and* 10,000*t. of Ore a Year.*

	47,000t. Impure Ores.		10,000t. Pure Ores.
Oper. No. 1.	10	Oper. No. 1.	5
" " 2.	16	" " 2.	8
" " 3.	8	" " 3.	4
" " 4.	5	" " 4.	3
" " 5.	2		
" " 6.	2		
" " 7.	1		
" " 8.	1		
" " 9.	4	" " 5.	2
" "10.	2	" " 6.	1
	51		23

MIXED METHOD.

Treatment.

1. Roasting impure and sulphrous ores in a reverberatory furnace.
2. Fusion of No. 1 with pure ores in a shaft furnace.
3. Roasting in stalls or a reverberatory furnace according to the price of fuel.
4. Fusion of No. 3 in a shaft furnace, with rich and pure oxydes, for blk. Cu.
5. Fining and refining in a reverberatory furnace.

TREATMENT IN RUSSIA.

(2.) Fusion in the Shaft Furnace.

No. 1.—*Charge.*

Sulphur on 0.660 / Oxydes, 0.340 } 1t. Cu		0.039
Scorias of blk. Cu.	0.115	0.100
Rich scorias of blk. Cu.	0.140	0.025
Debris of Furnaces,	0.015	0.005
		1.270

No. 2.—*Expense of Treatment.*

Charcoal,	0.413	4.07
Brasque,	0.020	0.14
Refractory matte,	0.033	0.15
Labor,	1.50	1.54
Transportation		0.21
Necessaries		0.22
		6.33f.

No. 3.—*Composition of the Blk. Cu.*

Cu	97 to 98.
Fe	2.
S	0.4
	100.4

(4.) Fusion for Black Copper.

No. 4.—*Cost per Ton.*

Wood, 6.07 at 1.20	7.28
Labor, 3.95 at 1.00	3.95
Repairs	2.68
Cost per ton	13.91f.

No. 5.—Cost Treatment for 1t. of Ore.

First fusion	6.33
Fusion of blk. Cu	1.53
Fining and refining	1.72
Repairs, &c	3.90
	13.48

COMPARISON OF METHODS.

No. 6.—Expense of Ordinary Method.

	Wood.	Charcoal.	Labor.
Roasting mattes,	1.5		3.00
Fusion for bl. Cu.		0.500	2.75
Fining,		0.150	0.60
	1.50	0.650	6.35

No. 7.—Expense of Mixed Method.

	Wood.	Labor
Roasting	0.07	0.35
Fusion	6.00	3.00
	6.07	3.35

No. 8.—Comparison.

Ordinary method	14.65
Mixed	11.23
Difference	3.42f.

TREATMENT OF OXYDES OF COPPER.

TREATMENT AT SZASKA.

No. 1.—Treatment.

1. Fusion of the ore for mattes.
2. Roasting the mattes.
3. Fusion for concentration.
4. Roasting concentrated mattes in 10 fires.
5. Fusion for black copper.
6. Fining the black copper.

No. 2.—Charge.

Oxydes at 1.9% of Cu	1000
Pyrites at 0.5% "	207
Scorias fr. blk. Cu. at 0.75% of Cu.	5
Limestone at 0.75% "	109
Height of the furnace	6m.
Quantity of mattes	18%
Yield of the mattes	8 to 14%

No. 3.—Fusion for Concentration.

Quantity of mattes produced.	13%
Yield of the mattes	30 to 35%

No. 4.—Resumé of all the Operations.

	Weight.	Wood.	Charcoal.	Labor.
1	1000		600k.	1.28
2	180	0.108st.	0.5	0.20
3	180		108	0.22
4	57	0.196	1	0.15
5	57		37	0.06
6	18		14	0.10
		0.304st.	760.5k.	2.01d.

Quantity of rosette Cu. produced, 14k.

No. 5.—Expense.

Loss in Cu	25%
Charcoal, 660k. at 10	7.60
Wood, 0.304st. at 1.20	0.36
Labor, 2d.	2.00
	9.96

TREATMENT AT PERM.

No. 1.—Charge.

Ore of 3% by weight	1
Dolomite "	0.30
Fuel,	0.30
Quantity of blast per m	5 to 6c.m.
Quantity smelted in 24h	3 to 4t.
Pressure of blast	0.03 to 0.04 of Hg.

No. 2.—Composition of the Black Cu. and Cast Iron.

Black Cu.		Cast Iron.	
Cu	94.0	Fe	83
Fe	4.5	Cu	10
Scoria,	1.5	Mn	3
		C	3
	100.00	Si	1
			100

No. 3.—*For* 1 *Ton of Ore.*

Charcoal,	0.700	6.37
Dolomite,	0.300	3.00
Labor,	2.28d	2.52
Repairs		.96
		12.85

No. 4.—*Products in One Campaign.*

Blk. Cu. in 6 furnaces	4200
Cast iron rich in Cu	3200
No. of campaigns in a year	8

No. 5.—1 *Furnace Produces.*

Blk. Cu.	201.6	210
" from east iron.	8.4	
Cast iron with Cu		153.6

No. 6.—*For* 1 *Ton of Cast Iron.*

Labor,	4d. at 90	3.60
Charcoal,	0.50k.	4.55
Repairs, &c		1
Cost of re-fusion		9.15

Quantity of cast iron per year, 140t.

No. 7.—*Expenses.*

Cost of re-fusion for 1t. of ore	0.219
Treatment in shaft furnace	12.85
	13.069

No. 8.—*Fining Furnace.*

Charge blk. Cu. at 80 to 95%.	3.200t.
Time for fusion	6 to 8h.
Time of operation	18 to 20
Cu. produced	2.800t.

No. 9.—*Expense of Fining.*

Labor,	6d. at 1.20	7.20
Wood,	6.20 at 1.25	7.75
Repairs		5.
For 1t. of blk, Cu		19.75
For 1t. of ore		0.233

No. 10.—*Refining.*

Each operation	3t.
No. of operations in 24h	.4
Quantity of Cu. treated	1480
Cu. produced	13.45

No. 11.—*Cost of Refining.*

Charcoal, 807	8
Labor, 2d.	4
Transportation in works	0.90
Cost of treating 1480t. of blk. Cu.	12.90
For 1t. of blk. Cu	8.71

No. 12.—*Recapitulation.*

Fusion of ore in shaft furnace	12.85
Fusion in cupoli	0.22
Fining	0.233
Refining	0.238
Special expenses	13.541
General expenses	8.41
	21.95

In the Ural Mts. 1t. of Cu. is worth	2500
The ton of east iron	120
Reduced to 1t. of ore this gives	66.35
Deduct cost of treatment	21.95
	44.40

This amount must cover the profits of the works, mining and transporting the ore.

TREATMENT IN THE WET WAY.

USE OF THE SULPHUROUS ACID.

No. 1.—*Sulphur Lost at Swansea.*

Ores smelted per w. at Swansea,	5000t.
They contain S	24 to 25%
This is equal to brown vitriol	3300t.
Worth per year	12,600,400f.

No. 2.—*Treatment.*

1. Simple condensation of S̈ or S̈ in water.
2. Manufacture of S̈ in lead chambers.
3. Reaction of the S̈ on metallic oxydes to produce sulphates.
4. Converting aluminous shales into Äl S̈

No. 3.—Treatment in the Wet Way.

1. Roasting, preparation, and washing sulphurous ores.
2. Treatment of oxydes by acids.
   a. The acids ($\ddot{S}$ or HCl) are purchased.
   b. The acid ($\ddot{S}$) is made from the ore.
3. Precipitation of the copper.
   a. By HS or a polysulphuret.
   b. By iron (cementation.)

No. 4.—Expense of Cementation.

Labor,,	0.56	at	2f.	1.12
HCl	22	at	35	0.77
Fe	3.5	at	0.15	0.52
Repairs				0.07
Transportation				0.52
				3.00

No. 5.—Details of the Operation.

Amount of ore treated per mo.	550t.
No. of men required	14
Time required for 100 of Cu.	140
Amount Cu. from 1t. of ore	5.4k.
Merchant Cu. obtained	2.7k.
2k. of Cu. is worth	6.75f.
Cost of treatment	3.42
	3.33

TREATMENT OF ORES OF LEAD.

(1.) ROASTING AND REACTION.

Reverb. Furnace. { 1. Carinthian Method. 2. French or Breton Method. 3. English, Spanish or Belgian Method.

Shaft Furnace.—4. Scotch or American Method.

(2.) ROASTING AND REDUCTION.

Impure Argentiferous Quartzose Ores without ZnS } Villas. Carthagena. Aguilas.

Poor Ores with Pyrites, Chalcopyrite, &c.—Lower Hartz.

(3.) PRECIPITATION.

Reverb. Furn.—Vienne in France.
Shaft Furn. —Silesia, Clausthal, Altenau, Lautenthal.

(4.) MIXED METHOD.

Przibam.	Stolberg.	Corphalie.
Pontgibaud.	Biache.	Schemnitz.

No. 1.—*Order of Fusibility and Volatibility.*

Fusibility.	Volatibility.
Lead.	Galena.
Subsulphuret.	Subsulphuret.
Galena.	Lead.

No. 2.—*Reactions.*

$PbS+3\ \dot{P}b\ddot{S}=4\ \dot{P}b+4\ \ddot{S}$ (1)

100 of pure Galena roasted gives.

$\dot{P}b$	66.3
$\dot{P}b\ddot{S}$	36.7
	103.0

$2\ \dot{P}b+PbS=3\ Pb+\ddot{S}$ (2)
$PbS+\dot{P}b\ddot{S}=2\ Pb+2\ \ddot{S}$ (3)
$3\ \dot{P}b\ddot{S}+PbS=4\ \ddot{S}+4\ Pb$
$\dot{P}b\ddot{S}+2\ PbS=2\ \ddot{S}+PbS+2\ Pb$
$PbS+2\ \dot{P}b=3\ Pb+\ddot{S}$

$\dot{P}b\ddot{S}+C=\dot{P}b+\ddot{S}+\dot{C}$
$\dot{P}b\ddot{S}+2\ C=Pb\ddot{S}+2\ \dot{C}$
$\dot{P}b\ddot{S}+4\ C=PbS+4\ \dot{C}$
$PbS+Fe=Pb+FeS$

(1.) ROASTING AND REACTION.

1. CARINTHIAN METHOD.

Treatment at Bleiberg.

No. 1.—*Periods in Process.*

1. Roasting.
2. Stirring.
3. Sweating.

No. 2.—*Analysis of Ore at Bleiberg.* 1856.

	Ore.	Pb
PbS	76.	66.3
$\dot{P}b\ddot{C}$	4.	3.1
ZnS	13.	
SbS	0.2	69.4
$\dot{C}a\ddot{C}$	5.0	
Insoluble,	0.4	
	98.6	

No. 3.—Amount of Gangue.

	Previous to 1856	1856.
Blende,	5% to 6%	6% to 8% sometimes 10 to 13%
Limestone,	4% to 5%	
Calamine,	1% " 2%	
Pyrites,	1% " 2%	4% to 5%
Clay,	1%	

No. 4.—Charge.

Charge	210k.
Sifted ore	$\frac{2}{3}$
Dust	$\frac{1}{3}$

No. 5.—Analysis of Ores after Roasting 3 to 4 hours.

Ṗb S̈	00.8	
Ṗb	24.5	
Pb	23.3	Pb²S
PbS	27.7	
ZnS	06.9	
FeS	02.2	
Ċa	04.2	
Ḃa S̈	03.4	
Clay,	02.0	
	103.0	

No. 6.—Ores roasted in a Furnace with a Double Hearth.

	12h.	18h.	24h.	30h.	36h.
Ṗb	7.0	16.1	20.0	44.3	69.2
ṖbS̈	2.4	3.6	12.5	26.0	14.0
PbS	89.0	79.2	66.5	29.0	12.1

	Pure PbS.	*PbS & FeS² in Small Pieces.*	*PbS upper Hearth.*
Ṗb	66.3	18.3	39.5
ṖbS̈	36.7	38.5	50.8
Ḟe		33.2	2.1
ŻnS̈ & Żn			7.4

No. 7.—Scorias from Treatment of Unroasted Galenas in Shaft Furnace at Clausthal.

	Good working. Top of the specimen.	Lower part.	Very good working.
S̈i	48.80	53.90	43.13
Ä̇l	4.62	4.40	4.76
Ċa	3.26	5.60	5.77
Ṁg	1.24	1.30	0.78
Ḟe	36.0	32.0	37.72
Ṁn			0.30
Ṗb	5.30	4.20	6.32

No. 8.—Analysis after the Pb ceases to form.

Ṗb S̈	14.0	
Ṗb	20.2	
Pb in grains,	18.3	
Fe	01.2	0.214
Zn	03.8	
PbS	06.1	
FeS	02.9	
ZnS	07.4	
Ċa	11.6	0.195
Clay,	02.8	
Ḃa S̈	05.1	
	93.4	

No. 9.—Residues at Bleiberg. Furnace, with two fireplaces.

	After 12 h.	After 16 h.
S̈i	9.4	15.1
Ṗb	6.83	9.30
Żn	10.5	10.4
F̈e	6.6	11.6
Pb (metal)	8.15	2.74
Ċa	7.2	8.1
PbS	42.60	18.87
ṖbS̈	9.5	9.5
C	1.2	0.9
Sb	2.24	3.20

No. 10.—Scorias. Treatment of very Rich Residues at Bleiberg.

	1	2
S̈i	27.85	30.55
Ä̇l	1.25	1.20
Ċa	11.75	15.28
Ṁg	0.33	0.28
Ḟe	47.84	41.15
Ṗb	1.70	2.15
Zn	4.10	6.25
S	2.20	2.34

No. 11—Loss of Pb allowed the Workmen.

Ores of	82%	loss allowed 2%
"	70%	" 7½%
"	65%	" 10 %
"	58%	" 14 %

No. 12.—Fuel Allowed.

For the charge of	210k.
Wood allowed	0.82st.
Prime given for all saved pr. st.	0.65f.
Charged for excess per st.	0.862f.

No. 13.—*Cost of Treatment.*

Bleiberg, 1856.

Ore yields by assay	67.3
" in treatment	62.7
Wood, 4.70 at 4.31	20.25
Labor, 4.70d at 2.28	10.72
Forger, 1.5k. of iron at .50	0.75
Forging	1.34
Repairs, &c	10.40
	43.46

20f. must be added for general expenses.

No 14.—*Cost of Works with* 2 *Furnaces.*

Cost of the works	15,000 to 20,000f.	
Ore treated per year	300t.	
For 1t. ore treated	50f.	
Int. for sinking fund 10%		5f.
Rolling capital	50,000f.	
Interest at 6%	3,000	
" per ton ore		10f.
Cost of direction		5f.
General expenses		20f.

No. 15.—*Roasting in a Furnace with a Double Fireplace.*

Charcoal used in 24h.	1360 to 1400
Ore treated	4000
Number of men	4
No. of days' work for 1t.	2

Charge of 200k. at 80% PbS yields 55% directly.

Residues yielding 46%–32% or 21.12

Total yield,	76.12
Loss,	3.885=5%
	80.00

(2.) BRETON METHOD.

Treatment at Albertville, France.

No. 1.—*Furnace.*

No. 2.—*Analysis of Ore.*

Galena,	88
Pyrites,	7
$\dot{B}a\ddot{S}$	4
Quartz,	1
	100

Pb contained	76%
Assay	70%
Treatment	64%
Total loss	12%
Wt. charged in hopper	1260k.
Loss of moisture 5%	60
Weight of ore	1200

No. 3.—*Analysis of Matte.*

	1	2
PbS	62.5	55.2
CuS	4.0	0.4
FeS	1.5	3.8
ZnS	0.0	11.0
Pb	32.0	0.0
Scoria,	0.0	29.6
	100.	100.

No. 4.—*Analysis of the White Crasses.*

$\ddot{S}i$	17.00
$\dot{P}b$	16.00
$\dot{B}a$	11.50
$\dot{F}e$	53.50
S	2.
	100.00

No. 5.—*Residues at Pesey, after* 16 *hours.*

$\ddot{S}i$	17.0
$\dot{P}b$	13.0
$\dot{F}e$	53.5
$\dot{B}a$	11.5
Pbs	5.0

*No.*6 .—*Expenses.*

Labor, 3.90d. at 1.92	7.49
Wood, 2.19st. at 6.25	13.69
Charcoal, 20k. at 50f. per t.	1.00
Wear & tear of tools	7.83
General expenses	10.00
Treatment of crasses, &c	7.48
	47.49

No. 7.—*Products.*

1000k. of ore yields.

Pb	579.76
Crasses, at 27% of Pb	200.20
Cadmia, at 37% "	6.86
	806.82

Pb from crasses, &c	62.
Pb from ore	580.
Total amount of Pb	642.

No. 8.—*Expenses from* 1834 *to* 1838.

Wood,	4.38st.	Charcoal,	31k.
Labor,	4.12d.	Tools,	21.8k.

Treatment at Poullaouen, France.

No. 9.—*Ore.*

Galena	78
Pyrites	10
Blende	8
Quartz	4
	100.
Contains Pb	67.5%
Assay	61%
Loss by treatment	15% to 16%

No. 10.—*Analysis of White Crasses.*

	After 16 h.	After 16 h. Huelgoet ore.		After 16h. Zinc ore.
S̈i	24	24.0	29.5	35.6
Ṗb	30	26.5	2.5	0.4
Ḟe	12	14.0	64.5	42.0
Żn	27	27.0	1.0	20.8
Ä̈l			2.5	1.0
PbS	4	5.0		
ṖbS̈	3	3.0		
	100			

No. 11.—*Expenses.*

Wood,	2.12st. at	3.66	7.75
Chareoal,	300k. "	40f. per t.	12.00
Labor,	5.33 "	1.03	5.49
Fe	25k. "	400f. per t.	10.00
General expenses			10.00
			45.24

(3.) ENGLISH METHOD.

No. 1.—*Furnace.*

Length of hearth	2.75
Width "	2.13
Length of grate	1.75
Width "	0.33
Width of bridge	0.45
Height of arch above fireplace	0.40
" " at flue	0.27
No. of doors on each side	3
Size "	0.27 × 0.23
No. of brick, refraetory	5000
" " common	2000
Amount of fire-clay	2500t.
Ordinary eharges, Newcastle	12 to 14 quint.
Wales,	21 "
Cornwall,	30 "
Time required	5 to 6h. or more.
Quantity treated in 24h.	4t.
Fuel per ton of ore	500 to 600k.
Labor	1 to 1.4d.

No. 2.—*Belgium.*

Hearth	4.50 × 2.90
Fireplace	1.30 × .40

No. 3.—*Dimensions of Reverberatory Furnaces.*

	Nouvelle Montagne.	Corphallie. 2 fireplaces.	Bleyberg. Old English Furnace.	Bleyberg. 2 fireplaces.	Binsfeld Hammer.	Flintshire.	Derbyshire.	England. (Rivot.)	Poullaouen & Holzappel.	Bleiberg In Carinthia.
Length of the hearth	2.50	4.12	2.70	4.70	3.05	3.00	3.30	3.70	3.33	3.47
Mean width do	1.40	1.80	2.90	2.90	3.05	3.00	3.30	2.40	1.95	1.40
Length of grate	1.50	1.05	2.00	2.00	1.83	1.40	1.40	1.40	1.30	1.35
Width of do	0.40	0.35	0.50	0.40	0.61	0.65	0.65	0.65	0.50	0.47
Width of the bridge	0.40	0.45	0.60	0.60	0.71	0.80	0.35	0.46	0.56	0.30
Height above the grate	0.60	0.50	0.35	0.35	0.30	0.30	0 55	0.50	0.40	0.10
do do hearth	0.25	0.10	0.30	0.30	0.30	0.12	0.40	0.20	0.30	0.10
Height of the arch above the bridge	0.20	0.17	0.30	0.30	0.30	0.50	0.40	0.40	0.30	0.25
do above the hearth	0.38	0.27	0.60	0.60	0.55	0.62	0.80	0.60	0.60	0.60
do do at the flue	0.38		0.35	0.60	0.30	0.25	0.25	0.30	0.50	0.60

No. 4.—Analysis of Crasses.

	Holzappel after 16h.		*Birmingham treating* PbS̈.		*Katzenthal ore with* As *and* Ph.
S̈i	10.0	S̈i	29.4	S̈i	27.6
Ṗb	38.9	Ṗb	15.6	Ṗb	11.0
Ḟe	5.6	Ḟe	13.4	Ḟe	26.2
Żn	30.5	Ċa	28.4	Żn	3.4
Ṁn	2.0	Ä̇l	5.7	Ṁn	4.6
PbS	5.0	PbS	5.5	Ä̇l	1.6
Ṗb S̈	8.0			PbS	4.0
				P̈h	15.0
				ĊaS̈	4.6

No. 5.—Residues at Grassington, Derbyshire, treating Carbonates with Barytic Gangue.

Ṗb	34.0
Ḟe	3.0
ĊaS̈	10.5
ḂaS̈	51.0
CaFl	1.5

No. 6.—Residues at Lea, Derbyshire, Treating Carbonates with Barytic Gangue.

	Without CaFl.		Rich Scorias.	
Ḟe	4.5	2.0	15.4	5.6
Żn		2.0	7.2	8.0
Ċa	8.0	8.0	16.0	14.7
PbS			17.6	2.0
Ṗb S̈	22.0	9.0	12.0	30.0
ĊaS̈	22.5	33.0	1.6	5.6
ḂaS̈	25.0	30.0	22.0	24.4
CaFl	16.0	13.6	7.2	8.5

No. 7.—Analysis of Lead.

	Spain.	*England.*
Pb	99.84	99.75
Cu	0.13	0.20
Sb	0.03	0.05
Ag	0.0038	0.006

No. 8.—Select Lead from England.

Pb	99.98
Sb	0.015
Fe	0.0008
Zn	0.0042
Cu	traces.

No. 9.—Expense.

Coal,	300 to 320	at	14.50 pr. t..	4.65
Labor,	3.5d	"	2.25.....	7.80
Fe	15k.	"	300f. pr. t.	4.50
Repairs.....				2.55
				19.50

When ores assay..... 67% to 68%
They yield..... 61%

No. 10.—Analysis of Galena treated in a Reverberatory Furnace, with two Fireplaces.

	Charge in the furnace during				Residues taken out after 16h.	Residues. taken out after 12h*
	3h.	6h.	9h.	12h.		
Ṗb S̈.....	8.08	11.10	10.27	14.47	6.43	6.47
Ṗb.....	1.43	14.98	16.48	18.10	9.30	6.83
PbS.....	71.54	50.27	41.37	25.29	16.34	36.91
Pb.....	0.65	6.70	6.70	6.85	2.74	8.15
Total.....	81.70	83.05	74.82	64.71	34.81	58.36
S found.....	11.92	9.20	7.52	7.22	3.10	6.60
Zn.....	4.28	4.29	5.13	6.04	8.33	8.39
Pb produced directly from 100 k. galena.....		5.	30.	51.	67	56
Yield of Pb in Ag.....		570	460	250	200	240
Lead contained in residues by the dry assay.....	78.6	79.8	72.4	63.1	32.8	55.4

*After an elevation of temperature.

No. 11.— *Comparative Diagram of Nine Experiments in Reverberatory Furnaces, with the same Ore.*

Yield of the Galena 79%

		1	2	3	4	5	6	7	8	9
Charge	kl.	1000	1000	800	1000	1000	600	1600	2000	2000
Time of one charge	hr.	9	9	9	9	12	12	16	16	12
Lead obtained	kl.	627.7	560	468	477	630	398	1096	1306.4	1036
White crasses obtained	kl.	153	290	225	354	223	80	158	310	744
Yield of the white crasses	%	39	50	44	74	35	24	22	30	62
Lead contained	kl.	59.8	145	99	262	78	19.2	34.79	93	463
Direct yield	%	62.77	56.0	58.5	47.7	63.0	66.3	68.5	65.3	51.8
Yield, including the lead in white crasses	%	68.75	70.50	70.87	73.9	70.8	69.47	70.67	69.97	74.86
Loss on 100 kl. of ore	kl.	10.25	8.5	8.13	5.1	8.2	9.53	8.33	9.03	4.14
do do of lead contained	kl.	12.97	10.7	10.3	6.45	10.4	12	10.5	11.4	5.2
Coal for 100 kl. of galena	kl.	712	562	633	506	700	667	917	734	375
Labor do do	fr.	3.75	3.75	4.70	3.75	5.00	8.33	7.91	6.83	4.75
Expenses of the forge do	fr.	4.80	2.00	2.40	2.00	3.20	4.80	3.20	2.40	0.80
*Cost of fusion in Reverberatory furn.	fr.	19.23	14.18	16.59	13.34	18.70	23.13	24.86	19.74	11.17
†Cost of treatment of residues	fr.	3.82	7.25	7.00	8.85	5.57	3.32	2.47	3.87	9.30
Total cost of fusion	fr.	23.05	21.43	23.59	22.19	24.27	26.45	27.33	23.61	20.47
‡Lead in white crasses	kl.	53.8	130.5	112	236	70.2	28.8	19.56	41.8	208
Total lead obtained	kl.	681.5	690.5	697	713	700.2	691.8	704.56	695	726
Value of this lead (at 50fr.)	fr.	340.75	345.25	348.50	356.50	350.10	345.90	352.28	347.50	363.00
Value of ton of Galena	fr.	317.70	323.82	324.91	334.31	325.83	319.45	324.95	323.89	342.53

*Counting only three posts. †At 25 fr. the 100 kl. ‡Counting on a loss of 10 per cent. in the shaft furnace.

1, 2, 3, 4, 5, English Furnaces. 6, Belgian Furnace at Prayon. 7, 8, 9, Furnace with two Fireplaces.

No. 12.—Comparative Table of the Treatment of Lead Ores, in Reverberatory Furnaces.

	Wales and Yorkshire.	Derbyshire.	Binsfeld-Haemer (Stolberg.)	Poullaouen.	Corphalie.	Bleiberg.	Nouvelle Montagne.	Holzappel.
Weight of charge.....kl.	1000	800	1000	1300	1400	2900	600	1300
Time of charge..... h.	6	6	9	16	16	12	12	12
Galena treated in 24h..kl.	4000	3200	2667	1950	2100	4000	1200	1950
Pb produced daily....kl.	2520	1984	1024	917	1153	2200	724	980
In the Galena..... %	78	70	68.8	66	68.49	80	70	62.9
Direct yield.....kl.	63	62	38.4	47	54.9	55	60.33	50.3
White crasses & residues in 100 of ore.....kl.	25	12	42.2	33	35.6	32	18.3	30.82
Yield of white crasses and residues.....%	40	30	64.8	39	22.3	66	26	25
Pb in white crasses, in 100k. of ore.	10	3.6	27.36	12.54	7.94	21.12	4.75	77
Volatilized substances in100k. of ore.			3.5		5.84	4.10		2.00
Yield of volatilized substances.			40		30.	42		29.48
Volatilized substances in 100k. of ore.			1.40		1.75	1.72		0.59
Total yield without condensed substances.*	73.0	65.6	65.8	59.5	62.84	76.12	65.08	58.00
Loss in 100k. of ore.†	3.5	2.9	1.6	5.0	3.89	2.16	3.50	4.3
Loss on 100k. of Pb in ore.	4.48	4.14	2.32	7.57	5.67	2.70	5.00	6.86
Fuel in 24h.	2000	2000	2000	4.5c.m. wood 450k. coal.	1200	1400	600	1040k. coal. 20.6 charcoal. 0.418c.m. wood.
Fuel for 100k. of Galena.	500	656	750	808k. wood. 135k. coal.	5.70	350	500	590k. coal. 0.279c.m. wood. 15k. charcoal.
Fuel for 100k. of lead.	80	100	200	379k. wood. 63k. coal.	100.	64	83	295k. coal. 0.139c.m. wood. 75k. charcoal.
Val. fuel for 100k. Galena.‡	5.00	6.56	7.50	From 8 to 9	5.70	3.50	5.00	13.00
Labor in 24h. 2.50f. pr day.	10.00	10.00	10.00	10.00	17.50	20.00	10.00	10.00
Labor for 100k. of Galena.	2.50	3.10	3.75	5.13	8.33	5.00	8.33	5.13

*The quantity condensed depends not on the treatment but the apparatus of condensation. †In Reverb. Furnaces only. ‡The coal is estimated at 10f. per ton.

No. 13.—*Experiments to determine the weight of the Charge in the Reverberatory Furnace at Corphalie in* 1860.

	Argentiferous Galena from the Rhine.		Galena of Meuse, France.	
Charge	1600	1300	1600	1300
Yield	69.604	78.88	68.118	69.835
Direct Yield	44.113	59.55	51.057	54.876
Pb contained in the crasses	15.389	11.50	10.34	11.805
Total Yield	59.502	71.05	61.397	66.181
Units lost	10.102	7.83	6.721	3.654
Percentage of the Pb lost	14.513	9.92	9.86	5.23

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4. SCOTCH METHOD.

No. 1.—*Analysis of Crasses at Bleiberg.*

	Product.
Ṗb	37.7
Ż̇n	19.2
Ḟe	19.5
Ċa	8.8
Ṁg	1.4
Ä̇l	1.7
S̈i	5.3
S	5.
	98.6

No. 2.—*Losses Allowed.*

Ore of 74% loss of 10% of Pb allowed.
" 72% " 11% "
" 70% " 12% "

No. 3.—*Details at Bleiberg for* 1866.

Blende, pyrites & lime in the ore	10%
Assay yield of the ore	72.6%
Furnace yield	63.%
Loss by treatment	9 to 10%
Loss in Pb	15%
No. of tons in 24h	3t.
No. of men in 12h	2

Fuel for 1t of ore.

Wood	41k.
Charcoal	113
	1.54k.=1.73st.
in reverberatory furnace	4.7st.

No. 4.—*Expense for* 1*t. of Ore.*

Labor.

Smelters, 1.33 / Laborers, 2.50	10.50
Wood and charcoal, 154k	9.21
Repairs of tools	1.17
Transportation, treament of crasses.	5.85
	26.73

No. 5.—*Przibam in Bohemia.*

Assay	75%
Loss of Pb	7.67
No. of tons in 24h	4.
No. of men in 24h	5

Fuel for 1t of ore.

Wood, 57 / Charcoal, 109	166k.

No. 6.—*Missouri.*

Wood alone.

Wood, 200k.	or .60st.

Charcoal alone.

Charcoal	3.5 hec.
Quantity of ore treated in 24h.	5t.

(2.) ROASTING AND REDUCTION.

WORKS AT VIALLAS, DEPT. OF LOZERE, FRANCE.

No. 1.—*Composition of the Ore.*

Pb	45
S	7
Gangue,	48
	100.

No. 2.—*Analysis of the Roasted Ore.*

Ṗb	50.50
Żn	1.50
Ṡb	0.50
Ḟe	6.00
ṖbS̈	24.70
ḂaS̈	7.00
PbS	1.50
ZnS	traces.
S̈i Clay, &c.	8.30
	100.

No. 3.—*Details of the Operation.*

Pb contains	63%
Assay	58 to 60%
Yield per quint in Ag	360 to 380g
Vapors contain Pb	25 to 30%
Hearth bottom yields Ag, per quint	1t.
Charge	700 to 900
Time	16h.
Quantity in 24h	1000.

No. 4.—*Expense for* 1*t. of Ore.*

Coal, 0.4 to. 5 at 21.5	9.99
Labor, 3d at 1.75	5.25
Repairs, tools, &c	0.49
	15.73

No. 5.—*Dimensions of the Furnace.*

Height above working table.	1.70
Width at throat	0.50
" tuyere	0.45
Length in direction of tuyere.	1.00
Diameter of tuyere	0.035
Height throat above tuyere.	1.30 to 1.35
Thickness refractory material	0.50
" " breast	0.12

No. 6.—*Charge.*

Roasted ore	1000
Scoria of same operation	500
ḂaS̈	30
Roasted iron ores	60
	1590k.

No. 7.—*Analysis of Scorias.*

	1	2	3	4	5	6	7
S̈i	36.7	36.1	38.0	39.4	35.	34.	34.2
Ṗb	4.	4.41	4.0	11.76	6.	7.	9.2
Ḟe	23.33	20.8	30.0	21.	26.0	21.9	
Ä̇l	3.50	trace			3.5	4.00	
Żn	4.50	6.50	4.20	4.5	4.00	5.85	
Ḃa	18.30	23.10	14.00	14.00	14.00	14.33	
Ċa	9.00	8.70	9.	9.	8.50	9.50	
Ṁg	.50		trace		1.60	2.00	
S̈ & S		0.39			0.50		
	99.83	100.	99.00	99.66	99.10		

1, 2 & 3 are the usual composition. 4, 5, 6 & 7 are the result of engorgements.

Assay generally ..... 2 to 6% Pb

Yield per quint. in Ag 25 to30g

No. 8.—*Expense for* 1*t. of Ore.*

Coke,	510	at 50.	25.50
Labor,	2	at 1.50.	3.00
Coal for blast,	0.125	at 21.50.	2.50
Roasted iron ore,	0.060	at 36 .	2.16
Repairs, &c			1.30
			34.46

WORKS AT CARTHAGENA, SPAIN.

No. 1.—*Roasting Chambers.*

Roasting chamber contains	5 to 6t.
Time of roasting	10 to 15d.
Cost of roasting 25t	50 to 75f.
Cost per t. of roasted ore	2.75 to 3.75

No. 2.—*Details of Furnace.*

Height from tuyere to throat,	0.85 to 1.25 & 1.30
Depth	0.84 to .90
Width	.70 to .74
Brasque, Clay	$\frac{2}{3}$
Brasque, Charcoal	$\frac{1}{3}$

Charge.

Roasted ore	150 to 200
Scoria with 1½% Pb	100

No. 3.—*Details of Treatment.*

Quantity treated in 24 hours.

Ore	4600k.
Scoria	1840k.
Pb produced	940k.
Pb containing per quint. in Ag.	250g.
Pb extracted	20.43%

Expenses for 1t. of Ore.

Fuel	15.80
Labor	5.90
Repairs	0.54
	22.24f.

For 100t. of Pb.

Fuel	77.50
Labor	29.00
Repairs	2.65
	109.15f.

No. 4.—*Detatls of Atmospheric Furnace.*

Exterior diam. of masonry	2.35 to 2.40
Height from hearth to arch.	2.50
" " throat.	1.75
Width at tuyere	1.16
" middle	1.29
" throat	1.21
Flue next the furn. (elipsoide.)	1.20
" " chimney "	0.80
Chimney at base	0.85 to 0.90
" top	0.75 to 0.80
Chimney for 4 furnaces	1
Cost of furnace	21 to 2.200f.
" chimney	14 to 1.500f.

No. 5.—*Charge.*

Baskets of ore, 7k. each	50 to 60
" scorias, $\frac{1}{6}$ crasses	10 " 12
" coke	6 " 7

A charge for 24 hours.

Ores	9200k.
Scorias	23 to 2700k.
Fuel	1530 to 1610k.
Assay of the charge	11 to 12%
Yield in the furnace	9%
Loss	2.5 to 3%

No. 6.—*Expense for* 1*t. of Ore.*

Fuel	11.23
Labor	2.93
Tools, &c	1.70
	15.86

No. 7.—*Expense for* 1*t. of* Pb.

Fuel	122.35
Labor	3.18
Tools, &c	1.95
	127.48

Fuel used 16 to 17%

2 parts of ore for 1 of metal.

TREATMENT OF THE CRASSES AND SLAGS.

No. 1.—*English Slag Hearth.*

Length	.63
Width	.75
Height	.97
Quantity in 24h	9 to 10k.
" of coke	15 to 20%
Scorias contain Pb	5 to 6%

No. 2.—Use of Cold and Hot Blast.

28t. of Scoria with cold blast.

Labor	84.58
Coke, 7t. at 30.86	214.37
	298.85

35t. of Scoria with hot blast.

Labor	84.58
Coke, 5.85t. at 30.86	179.16
Charge of Pb at 2.06	22.91
	286.65

WORKS AT OCKER.

No. 1.—Charge.

Roasted ore of 6 to 10% Pb	1000
Sometimes roasted mattes.	
Scorias of 4 to 5% Pb	280 to 300
Litharge cupel bottoms	10
Sometimes debris of furnaces.	1300

Product.

Pb	85
Mattes	100
Cadmia	15
Scoria	850 to 900
Zn	1 to 2
	1050 to 1100
O, S & H	250 to 200
	1300 1300

No. 2.—Details of the Operation.

Ore roasted in 24h. . . . . 3t.

Fuel for 1t. of Ore.

Coke	170
Charcoal	200
	370k.

(3.) METHOD BY PRECIPITATION.

WORKS AT VIENNE, DAUPHINY.

No. 1.—Composition of Matte.

FeS	91
PbS	9
CuS	traces
	100

No. 2.—Composition of Scorias.

	Compact.	Crystaline.
Si	29.5	35.6
Fe	65.0	41.8
Zn	1.0	20.0
Pb	2.5	0.4
Al	1.0	1.0
Ca	1.0	1.0
	100	99.8

No. 3.—Fuel used.

Vienne, per 1t. of ore	600k.
Poullaouen, "	700k.

No. 4.—Scorias from Fusion of Scorias.

	Rich.	Poor.
Si	35.2	34.8
Pb	26.8	6.6
Fe	20.0	35.0
Zn	5.2	0.0
Al	4.6	4.8
Ca	4.4	7.0
Trace mattes	2.2	9.0
	98.4	97.2

WORKS AT TARNOWITZ.

No. 1.—Dimensions of the Furnaces.

	1 tuyere.	2 tuyeres.
Height,	5.10m.	5.10m.
Depth at throat,	0.76	0.82
" tuyeres,	1.12	1.35
Width at throat, warm,	0.60	0.70
" breast,	0.45	0.60
Width at tuyere, warm	0.60	2.05
" " breast	0.55	2.05

No. 2.—*Charge for* 1*t. Granulated Ore.*

Metallic iron	150
Puddling Scorias	150
Pb Scorias	400
Coal	330

Products.

Pb with 600 to 700gr. Ag	700k.
Mattes	350

No. 3.—*Charge.*

	Old.	New.
Ore	1000	1000
Cast iron	145	720
Forge scorias Ṙ S̈i	153	120
Scorias of same operation.	350	360
	1648	1620

No. 4.—*Products.*

	New.		Old.
Lead	700		635
Matte 5 to 9% Pb	309	6 to 8%	245
Rich scorias 2 to 4%	390	2 to 4%	330
Poor " ½ to ¾%	258	1 to ½%	360
Loss	50		100
	1690		1670

No. 5.—*Details of the Fusion.*

In 24 hours.

	New.	Old.
Total yield of Pb	72 to 73%	69 to 70%
Coal per ton of ore.	435	384
Labor	1.50d.	1.50d.
Charge	8 to 9t.	6 to 7t.
Cost	22f.	20f.

No. 6.—*Impure Pulverulent Ores.*

Charge.

Ore in bricks at 44%	1000	1270 to 1300
Iron, 6 to 10%	60 to 70	
Forge scorias	210 to 230	
Rich scorias	720	

No. 7.—*Charge for* 1*t. of Ore in Bricks.*

Metallic iron	60
Puddling Scorias	220
Pb Scorias	400
Coal	500

Product.

Pb	400
Mattes	120

Charge in 24 hours.

Granulated ore	6000 to 7000k.
Ore in bricks	3000 to 3500

No. 8.—*Smelting of Roasted Mattes and Crasses.*

Charge.

Rich scorias	1750k.
Debris of furnaces	250
Condensed products in bricks	250
Roasted mattes	1250
Old Pb scorias	1500
Iron	100

In 24 hours.

Pb Produced	200 to 250k.
Coal consumed	10 hect.

No. 9.—*Mattes at Andreasberg* (*Arsenical Ore.*)

Pb	35.68
Fe	31.54
Cu	3.79
As	1.07
Sb	1.49
S	23.97
Mn	0.25

No. 10.—*Mattes at Tarnowitz.*

	Common and normal matte.	Normal working.
Fe	9.758	13.39
PbS	15.54	38.09
FeS	73.49	42.75
ZnS	21.88	5.52
AgS	0.018	0.13

No. 11.—*Scorias at Andreasberg,* (*arsenical ore.*)

S̈i	34.82
Ä̇l	9.77
Ċo	11.72
Ṁg	1.21
Ḟe	24.61
Ċu	0.33
Ṗb	12.31
Ṁo	0.54
K̇	2.34
S̈b	0.21
Ä̇s	0.26

No. 12.—*Scorias at Tarnowitz.*

S̈i	35.65
Ä̇l	2.19
Ċa	6.54
F̈e	44.90
Ż̇n	0.73
PbS	9.70

No. 13.—*Product.*

Pb	390 to 400
Mattes 6% of Pb	120 " 130
Rich scoria	520 " 530
Crasses	40 " 50
	1070 " 1110

No. 14.—*Details of the Operation.*

Ores passed in 24h	3.50t.
Coal per ton of ore	717k.
Labor	2.60d

No. 15.—*Charge in* 1850.

Roasted mattes	250
Rich scorias of operation No. 2	350
Old "	300
Debris of furn., crasses, &e., of 2.	50
Cadmias with lime	50
	1000k.
Cast iron	24
Forge scorias	243
Limestone	39
	1106k.

No. 16.—*Quantity Treated.*

In 24 hours.

Charge smelted	10t.
1000 of charge give Pb	40 to 45k.
Fuel per ton of charge	180k.

No. 17.—*Expenses for the Year,* (1860.)

For 1000k. of Galena.

Galena,	1000k.	300.00f.
Iron,	162	11.01
Coal,	424	4.24
Scorias from puddlage,	230	1.01
Transportation		2.42
Preparation of charge		1.51
General expenses		9.45
		329.64f.
Cost without the ore (300.00)		29.64f.

By 100k. of Pb

Ore,	165. k. at 300f. the t.	49.40f.
Iron,	26.70 " 6.80f. 100k.	1.83
Coal,	70. " 10f. the t.	0.70
Puddling Scorias,	38 at 4.40%	0.17
Founders		0.40
Preparation of charge		0.25
General expenses		1.56
		54.31f.
Cost without the ore (49.40)		4.91f.

No. 18.—*Analysis of Lead from Tarnowitz.*

	Impure Lead.	Mercantile. 1st quality.	2d quality.
Sb	0.196 to 0.207		0.436
Fe	0.237 to 0.325	traces	0.047
Zn	0.568 to 0.372	traces	0.135
Ag	0.01 to 0.075	0.003	0.015

WORKS AT ALTENAU AND CLAUSTHAL.

No. 1.—*Composition of the Ore.*

Galena,	70
Quartz,	14.5
ĊuC̈	3.2
ḞeC̈	7
ḂaS̈	1.8
Slate,	4.5
	100
Yield,	55%

Ag 100g. in 100k.

No. 2.—*Charge.*

Ore, at 55%	1000	550
Litharge & cupel bottom	110 at 88%	97
Impure litharge abstriehs,	37 at 83%	31
Lead scorias fusion for matte (Ṙ S̈i	500 at 6%	30
Cast iron & serap iron,	110	
Scoria same op., (Ṙ2S̈i)	400 at 7%	28
	2157	736

No. 3.—Clausthal.

Charge for 100 of Galena.

Iron	11.2
Cupel bottoms, litharge	16.6
Scorias	20.6
Scorias from treatment of matte.	49.9

By 24 hours.

Galena 4200, or of charge..... 8000k.

Fuel used, 41 chareoal for 100 ore.

No. 4.—General Composition of Scoria.

Si	45 to 50
Fe	36 " 35
Ca	7 " 5
Pb	6 " 5
Ba Al Mg	6 " 5

No. 5.—Analysis of Scorias at Altenau.

Si	53.82
Al	3.82
Ca	5.37
Mg	1.09
Fe	25.90
Mn	2.74
Pb	4.79
Fe^2S^3	3.16

No. 6.—Analysis of Mattes at Clausthal.

	Ordinary work. 1	2	Crystaline matte.
Pb	41.50	36.00	73.35
Fe	34.05	33.20	9.81
Cu	0.36	traces.	0.40
Zn	0.36	2.50	0.20
Ag	0.12		0.12
Sb	0.66	5.30	0.40
S	23.82	22.0	15.34

No. 7.—Products Obtained.

Pb	545 at 95%.....	518
Mattes,	396 " 35%.....	138
Scorias,	1166 " 5 %.....	58
Loss by reduction, 50.....		21
	2157	735

Products for 100 of PbS or 192.3 of ore.

Lead	53
Matte	44
Scorias	143
Deposits	8

No. 8.—Expenses.

Preparation of charge for 1t. PbS.	1.38
Transportation of scorias.....	0.48
Founders	1.98
Transport. & storage of products.	2.06
Labor	5.90
Iron, 119k. (14.50 the 100k.)...	17.22
Chareoal, 428k.....	19.00
	42.12

No. 9.—Concentration of Mattes.

No. of Roastings 6 or 7.

2d smelting in cupola.

Roasted mattes.....	100
Metallic iron.....	3
Scorias from fusion of ore.....	100
Cupel bottoms.....	17.6
Debris of furnaces.....6 or 10	
Charcoal.....	3
Coke	24
Total.....	27%

Produets.

Lead.....	34%
Mattes	37%
Scorias.....	160.7
Deposits.....	0.3

No. 10.—General Composition of the Pb.

Pb	95
Cu	1 to $\frac{1}{2}$
Ag Sb S Fe	4 to 3

No. 11.—Lead from Clausthal.

	1	2
Pb	99.72 99.79	97.69 98.51
Cu	0.13 2.07	0.06 0.14
Sb	0.03 0.36	1.10 1.34
As	0.36	
Zn	0.88	
Ag	0.0032 0.0098	

No. 12.—Hard Lead from Clausthal.

Density,	10.464
Pb	86.34
Cu	0.68
Sb	12.08
	99.00

No. 13.—*Hard Lead from Altenau.*

Density,	9.373
Pb	79.36
Cu	0.04
Sb	20.57
Fe	0.03
	100.00

No. 14.—*Details of the Operation.*

Charge in 24h	8t.
Corresponds to ore	3½ to 4t.
Campaign lasts	8 to 9w.
Fuel for 1t. of ore	450

No. 15.—*Resumé*

	Weight.	Charcoal.	Cast Iron.	Labor.	Transportation.	Wood.
Fusion of ore	1000	450	110	3.20	0.70	
Roasting 1st matte	396			0.09	0.28	22
1st fusion of matte	396	142	10.5	0.96	0.13	
Roasting 2d matte	130			0.03	0.09	8
2d fusion of matte	130	47	3	0.32	0.05	
Roasting 3d matte & 3d fusion	43	16	1	0.12	0.05	3
Roasting 4th matte & 4th fusion	14	5	0.5	0.04	0.02	1
Fusion of cadmias & dust	100	40	7	0.20	0.04	
1000k. require		700k.	132k.	4.96f.	1.36f.	34k.

No. 16.—*Recapitulation.*

Charcoal, 709 at 30	21.00
Cast iron, 132 at 160	21.12
Labor (fusion) 1.80	4.96
Labor (transportation) 1d	1.36
Wood for roasting, 34k. at 17	1.58
	49.02

With cupellation, &c.

Charcoal	830k.
Wood	125k.
Faggots	340k.

No. 17.—*Expense of all the Operations.*

Fusion of ores,	42.12
Roasting of mattes	2.25
Smelting mattes, 1st time	7.15
" " 2d, 3d & 4th time	4.30
Smelting deposits & debris	3.50
Cupellation (774k. Pb)	10.85
Revivification of litharges	5.33
	75.50f

TREATMENT AT LAUTENTHAL.

No. 1.—*Charge.*

Ore,	1000	at 63%.	630k
Litharge, & cupel botm.	110	" 88%.	97
Impure litharges,	40	" 83%.	33
Pb scorias from mattes,	900	" 6%.	54
Scoria same operation,	800	" 6%.	48
Cast iron,	110		
	2960		862

No. 2.—*Products.*

Pb	438	at 95.5%	422
Mattes,	524	" 50.0%	262
Scorias,	1900	" 6.0%	114
Loss,	98		64
	2960		862

No. 3.—*Analysis of Scorias.*

$\dot{S}i$	41.00
$\dot{A}l$	2.55
$\dot{C}a$	6.82
$\dot{M}g$	0.62
$\dot{F}e$	33.72
$\dot{M}n$	1.26
$\dot{P}b$	7.25
Fe^2S^3	1.58
ZnS	3.60

No. 4.—*Charge of Mattes, &c.*

Roasted mattes	1000
Rich scorias	800 to 900
Cupel bottoms	167
Assays	14
Cast iron	28

No. 5.—*Quantity Treated.*

Quantity in 24h	4t.
Pb produced	350k.
Mattes	336k.

No. 5.—Treatment of Dust.

Roasted mattes	250
Scorias from fusion	900
Debris crushed and roasted	250
Pb scorias from treatment of litharge	200
Cupel bottoms, abstracts	100 to 200
Cast iron	70

No. 6.— Comparison of Yield at Clausthal and Lautenthal.

	Clausthal. Pb	Clausthal. Ag	Lautenthal. Pb	Lautenthal. Ag
Fusion of ore,	55.99	71.34	44.26	62.59
1 fusion mattes	16.02	21.39	16.93	25.38
2 " "	5.58	6.94	5.06	8.78
3 & 4 " "	1.42	1.64	1.41	3.61
Fusion cadmias,	4.30	4.81	7.25	0.60
	83.31	106.12	74.91	101.06

No. 7.—Loss in Lead.

	Clausthal.	Altenau.	Lautenthal.
Smelting of ore,	1.28	2.48	6.3
" mattes,	0.60	1.91	
Cond. products.		0.95	
Cupellation,	10.70	6.17	8.0
Revivification,	1.79	0.39	2.0
Manufac'g hard Pb		0.05	
	14.27%	12.78%	16.3%

(4.) MIXED METHOD.

ROASTING THE ORES.

No. 1.—Analysis after Roasting.

Roasting 100k. galena in a Carinthian Furnace.

Ṗb	39.5
ṖbS̈	50.8
Żn & ŻnS̈	7.4
Ḟe	2.1

No. 2.—Analysis after Roasting.

Galena Roasted in Double-Hearth Furnace.

	1st period.	2d period.	3d period.	4th period.	5th period.
PbS	87.0	77.2	64.5	27.0	10.1
ṖbS̈	2.4	3.9	12.5	26.0	14.0
Ṗb	7.0	6.1	20.0	44.3	69.2

No. 3.—Roasting the Ore.

	Furnace with 1 hearth 8m. long.	Furnace at Pontgibaud.	Furnace with 2 hearths.	English Furnace.
Ore roasted in 24h kl.	4000	7200	2400	1620
Coal used "	680	2000	550	550
Coal for 100 of ore	186	260	230	400
Labor	1.80	2.40	1.67	1.30

TREATMENT AT PRZIBAM.

No. 1.— Composition of Ore.

Galena	45 Pb 39%
Blende	18
Quartz & ḂaS̈	20
Ferruginous limestone	15
S, As, Sb & Cu	2
	100

No. 2.—Dimensions of Furnace.

Hearth	4.75 × 3.50
Fireplace	1.40 × 0.80
Flue	0.30 × 0.24
Charge	1120k.

No. 3.—Charge.

Coal, 275k. at 19	5.22
Labor, { roasting, 1.8d / transportation, 0.6 }	2.93
Repairs	0.45
	8.60

No. 4.—Reduction Furnace.

Height above tuyeres	3.32
Height of the "	0.50
Width against "	0.70
" breast	0.63
Depth of furnace	0.95

No. 5.—Charge.

Roasted ore at 39%	1000
Litharge cupel bottoms... / Abstrichs & roasted mattes.	1.2.&300
Forge scorias	360 to 600
Cast iron	80
	1580 to 1800

No. 6.—Details of the Operation.

By campaign.

Ore	42112k.
Crasses	12712
Litharges	7000
Cast iron	2800
Puddling scorias	19208
Charcoal	1200h.

By 24 hours.

Ore, 2340 / Crasses, 700 / Litharges, 390	3430k.
Cast iron, 155 { 6.62% ore. / materials cont. Pb 4.52%	
Puddling scoria, 1070	30%
Charcoal, about	40%

No. 7.—Expense.

Charcoal,	507	at 50.77	...	25.74
Cast iron,	80	to 150	...	12.00
Forge scorias,	600k.	at 11.20	...	6.72
Brasque,	16k.	at 25.38	...	0.40
Clay,	0.28hc.	at 0.13	...	0.04
Labor, special,		2.30	...	3.50
" ordinary,		1.00	...	0.94
				49.34
Expense of roasting				8.60
				57.94

No. 8.—Cost of Treating 1t. of Ore.

Cost of roasting, 275k. / Charcoal for fusion, 523k.	798k
Cast iron	80k
Labor, { Roasting, 1.8 / Founders, 2.3 / Laborers, 1.6 }	5.7d
Forge scorias	500k

TREATMENT AT PONTGIBAUD.

No. 1.—Charge.

Charge	1000k.
Coal, per ton of ore	450k.
Lime on 2d hearth	3 to 4%
Quantity in 24h	4t.

No. 2.—Cost.

Coal,	35k.	at 34.5	12.02
Labor,	1.5d.	" 1.5f.	2.25
			14.27f.

No. 3.—Analysis of Ore.

Galena contains 52% Pb, assay 50%.	60.
FeS^2	10.
ZnS	5.
S & Sb	2.
$\dot{B}a\ddot{S}$	8.
Gangue	15.
	100.

No. 4.—Analysis of Roasted Ores.

	Porphyric ore.	Comby ore.	Careful roasting in old furnace no galena seen.
$\dot{Z}n$	3.9	4.1	5.2
$\dot{P}b$	35.6	40.6	16.7
$\dot{F}e$	17.0	14.1	20.7
$\dot{B}a\ddot{S}$	7.4	7.2	9.2
$\dot{P}b\ddot{S}$	6.7	7.1	8.1
PbS	1.4	5.7	6.1
$\ddot{S}i$	24.1	16.5	27.0
$\dot{M}g$	1.3	1.5	2.2
$\dot{C}a$	1.0	1.1	2.7
As & Sb	traces.	traces.	0.9

No. 5.—*Analysis of Scorias.*

	Old scorias.	Irregular working.	Good working	Good working.
Si	39.0	40.0	38.0	27.0
Al	1.5	1.7	1.4	7.6
Ca	11.0	15.0	24.1	13.0
Mg	2.1	3.2	2.9	
Fe	21.2	18.7	19.2	32.0
Pb	18.2	13.1	6.0	18.6
Ba	26.0	3.2	3.3	18.6
Zn	1.70	1.50	1.6	
S	1.00	2.30	2.1	

No. 6.—*Analysis of Mattes.*

	1	2
Pb	79.5	67.0
Fe	12.2	22.4
Zn	1.1	1.1
As	4.2	4.5
S	2.3	4.0

No. 7.—*Deposit at the Breast of the Furnace.*

Pb	80.1
PbS	9.0
As	4.1
CaC	2.8
S	4.9

No. 8.—*Charge.*

Roasted ore	1000k.
Lime	50
Old iron & cast iron	100 to 120
	1150 to 1170k.

No. 9.—*Quantity Treated, &c.*

In 24 hours.

Quantity treated	8 to 9t.
With 120k. cast iron, coke	65k.
" 100k. " "	80k.
Yield of 100k. of ore.	
Pb 40 to 42k.	52%
Loss, 20% with cupellation and patisonage	30%

TREATMENT AT BIACHE, ST. VAAST.

No. 1.—*Charge.*

Roasted ore	1000k.
Iron	100
Chalk	100
Charge	1200k.
Coke, per ton of ore	100k.

No. 2.—*Fuel used.*

In Large Furnace.

Fuel per ton of ore	280k.

In Small Furnace.

Fuel per ton of ore	330k.

No. 3.—*Details of a Campaign.*

By campaign.

Roasted & agglomerated ore	3,629,826k.
Crasses from refining and litharge scorias	303,121
Roasted mattes	207,700
Crasses from the furnace	33,355
Unroasted mattes	3,985
	4,177,987k.

Marl	470c.m.
Iron, { 10% of ore / 9% lead materials. }	378,598
Spath fluor & scorias from puddling	750,000

No. 4.—*Expense.*

Labor	3.45f.
Coke, 163k. 36f.	5.86
Coal, 35k. 20f.	0.70
Repairs	1.48
Iron, 104 (6f.)	6.27
Tools	0.57
Flux	1.20
Full cost by % of ore	19.53f.

No. 5—Smelting Roasted Ores & Residues of Reverberatory Furnace in Shaft Furnace, without using Metallic Iron.

Operations.

Roasting the ores in furn. with 2 hearths.
Smelting, with dark throat, keeping a nose of from 0.12 to 0.14

Charge.

Roasted ore	3000k.
Copper ore	1000
Lime or fluor spar	125
Scorias	5000
Coke	1200 to 1350k.

No. 6.—Dimensions of Shaft Furnace.

Height of shaft fr. tuyere to throat.	3.96m.
Depth of channel leading to front hearth, under tuyeres	0.42
Width of shaft at the warme, at level of tuyeres	1.70
do at breast, at level of tuyeres.	1.13
Depth of shaft " "	1.20
Brick partition above tuyeres	1.30
Thickness of partition	0.12
Width of each division at warme, at throat	0.73
do do breast, at throat	0.57
Depth do do do	0.85
Between tuyeres	0.70
Diam. of tuyeres	0.035
Pressure of blast	0.70
Quantity of blast	4.829
No. of eastings in 24 hours	4

Products.

Each easting metallic lead	200k.
Silver	5000 to 6000g.
100k. mattes containing lead	20%
100k. mattes containing copper	10%
100k. mattes containing silver	2000g
	5 to 6% Pb
72 scorias (per 100 of charge.)	200g. silver per t. of scorias.

Scorias contain $\ddot{S}i$, less than 30%

TREATMENT AT STOLBERG.

No. 1.—Roasted Ore.

$\dot{P}b$	61.9
$\dot{F}e$	2.9
$\dot{C}a$	8.3
$\dot{M}g$	2.6
$\ddot{A}l$	1.4
$\ddot{S}i$	19.5
$\ddot{C}$	1.4
S	1.00
	99.00

No. 2.—Charge.

Roasted ore	1000k.
Forge scorias	780 to 800
Lime	180 to 200
Charge	1960 to 2000k.

In 24 hours.

Quantity smelted	6 to 7t.
Coke per ton of ore	250k.
Quantity of mattes	1%
Scorias containing Pb	1%

No. 3.—Analysis of Scorias (Siliceous Ores.)

$\ddot{S}i$	34.45
$\ddot{A}l$	0.21
$\dot{C}a$	9.11
$\dot{M}g$	0.27
$\dot{F}e$	47.66
$\dot{P}b$	1.55
S	26
$\dot{Z}n$	29.
$\dot{C}u$	1.
FeS	4.

No. 4.—Double Refined Lead.

Pb	99.952
Cu	0.026
Sb	0.007
Fe	0.006
Zn	0.009

TREATMENT AT SELEGNEAUX.

No. 1.—Charge.

Ores made into bricks, with addition $\frac{1}{3}$ $\dot{C}a$ & 15% coke.

Red earth	$\frac{2}{3}$
Ores sulphurets	$\frac{1}{6}$
Ores carbonates	$\frac{1}{6}$
Puddling scorias	10%
Flux	15%

No. 2.—*Dimensions of the Furnace.*

Dimensions of shaft, at 1.50m.

Width	1.10m.
Depth	0.70
Width at throat	1.30
Depth at "	1.00
Pressure of blast	0.50 to 1.00

Products.

Lead	2000k.
Mattes	$\frac{1}{4}$

WORKS AT MEMBACH.

No. 1.—*Dimensions of the Furnace.*

Height	5.00m.
Width	0.80
Depth	1.00

No. 2.—*Charge.*

Campaign of 40 days.

Ores, 65,38%	158,251k.
Debris & residues	19,458
Iron scorias	150,000
Coke	35,000
Lead	99,698

Per 24 hours.

Roasted ores	3,956k.
Iron scorias pr 100 roasted ores.	95
Coke " " "	22
Lead	2,492

No. 3.—*Loss of Lead.*

Lost in roasting, 4%

	Roasted Ore.	Charge.	Lead Contained.
Pb lost	2.43%	1.19%	3.64%
Total loss (about)	6.50%	6.00%	9.00%

By treating the volatile products the loss of lead becomes 4 or 5%

WORKS AT BLEIBERG.

No. 1.—*Charge.*

Campaign of 20 days.

Residues reverb. furn. (65% Pb)	113,803k.
Puddling scorias	83,300
Flux	19,800
Coke	16,300

Product.

Lead	70,331k.

Per 24 hours.

Ore	5,690k.
Iron scorias	75%
Flux	17.40%
Coke	14.40%

Product.

Lead	35,165k.

No. 2.—*Analysis of Scorias at Holzappel, (Ores with much Blende.)*

S̈i	25.0
Ä̇l	1.3
Ċa	4.2
Ṁg	1.0
Ḟe	24.5
Ṁn	8.0
Ṗb	18.6

No. 3.—*Expenses.*

Labor per 24 hours.

Master workman, 2d	5.50f.
Assistant, 2d	4.50
Transportation, 5d	10.00
	20.00f.
Labor, at the blast engine	4.50
	24.50f.

No. 4.—*Percentage.*

	For 1t. of Ore.	For 100k. of Lead
Labor	4.31	0.70
Tools	0.80	0.13
Coal for engine, (600k. per d. 16f. the 100k.)	1.68	0.27
Repairs, labor	1.28	0.20
Repairs, materials	0.79	0.13
Puddling scorias (8f.)	6.00	0.97
Coke (32f.)	4.60	0.74
Flux	0.44	0.07
Total amount	19.90	3.21

WORKS AT CORPHALIE.

No. 1.—*Dimensions of the Furnace.*

Height	3.50m.
Size	1.00 × 1.00
Pressure of blast	0.25 to 0.35

Per 24 hours.

Materials with Pb (at 30%)	4000 to 5000k.
Puddling scorias	50 to 75%
Coke	18 to 22%

Scorias containing over 1% Pb are treated again.

Products.

Pb produced	1100 to 1200k.

No. 2.—Losses by Volatilization.

Ores.	Weight of ore treated.	Weight of Lead. Contained in the ore.	Produced.	Lost.	Contained in poor scorias thrown away.	Contained in deposits.	Lost by volatilization
Crude ore	32090	16276	13430	2846	808	2038	12.52
Roasted ore	36115	23630	21269	2361	542	1819	7.69

COMPARISON OF THREE PROCESSES.

No. 1.—Treatment in Reverb. Furnace, making poor Residues to be smelted in Shaft Furnace.

1000k. Galena (69.57%)

Products.

Lead ..... 603k.
Crasses, (19.8%) 36k. Pb 190
Crasses in shaft furnaee yield Pb 36k.

Loss in Reverberatory Furnaee.

% of ore 5.6
% of Pb eontained 8.03

Loss in Shaft Furnaee.

% of ore 0.86
% of Pb contained 4.30
Total Pb produced ..... 639k.
" " lost ..... 57.70k.
" " " for 100k. of ore .. 5.77
" " " for 100k. Pb cont'd 8.30

Expenses.

Reverb. furnace 24.70
Shaft furnace (19.25%) 8.71

33.41f.

Galena supposed 70%

Pb lost 58.10k
Value of this Pb (500) 29.05
Cost of smelting 33.41

Cost & loss ..... 62.46f.

No. 2.—Treatment in Reverb. Furnace, making rich Residues to be treated in Shaft Furnace.

1000k. Galena (69.35%)

Produets.

Lead ..... 427k.
Crasses (65%) 224k. Pb 364
Crasses in shaft furnace yield Pb 224k.

Loss in Reverberatory Furnaee.

% of ore 2.98
% of Pb eontained 4.30

Loss in Shaft Furnaee.

% of ore 3.25
% of Pb eontained 5.07

Total Pb produeed ..... 651k.
" " lost 42.50
" " " for 100k. of ore .. 4.25
" " " for 100k. Pb eont'd 6.13

Expenses.

Reverb. furnaee 16.40
Shaft furnaee (23.80%) 8.65

25.05f.

Galena supposed 70%

Pb lost ..... 42.91k.
Value of this Pb 21.95
Cost of smelting 25.05

47.00f.

No. 3.—Careful Roasting & Agglomerating without producing Pb, & smelting in Shaft Furnuce.

1000k. Galena (63.32%)

Produets.

931k. yield of roasted ore at 65.33%
573k yield Pb 61.57%

Loss in Roasting.

% of ore 2.44
% of Pb eontained 3.85

Loss in Shaft Furnace.

% of ore 3.76
% of Pb eontained 5.75

Total Pb produced ..... (57.3%) 573k.
" " % of Pb eontained 9.50

Expenses.

Roasting (per ton)	7.80
Shaft furnace (21f. per ton)	19.53
	27.33f.

Galena supposed 70%

Pb lost	66.50k.
Value of this Pb (50%)	33.25
Cost of smelting	27.53
Cost and loss	60.78f.

No. 2.—Resumé.

	1	2	3
Loss in Pb	58.30	42.91	66.50
Val. Pb at 50f. pr 100k.	29.05	21.95	33.25
Cost of treatment	33.41	25.05	27.53
Total expense & losses	62.46	47.00	60.78

REFINING LEAD.

No. 1.—Reverberatory Furnace for Refining Pb.

Length of hearth	2 to 4 m.
Width "	1.50 to 2.00
Depth of charge	0.30 to 0.40
Length of operation	12 to 60h

No. 2.—Furnaces at Freiberg.

	1861.	1864.
Length of hearth	2.86m.	3.71
Width "	2.14	2.86
Charge	5 to 6t.	8t.
Max. height of arch	0.90	0.90
" " bridge	0.33	0.33
Inclination of hearth	.1	.1
Charge	8.5t.	9t.
Weight of pig of Pb	50k.	
Coal used in 24h	750 to 900k.	
Time. Pb from ore or matte	15 to 16h.	
" litharge	4 to 5h.	
" erasses	60 to 80h.	

No. 3.—Analysis of Lead.

	Unrefined Silver. Pb	Refined silver. Pb	Arsenical Pb	Antimonial Pb	
Pb	97.72	99.28	87.60	90.76	87.60
As	1.36	0.16	7.90	1.28	0.40
Sb	0.72	traces	2.80	7.31	11.60
Fe	0.07	0.05	traces	0.13	traces
Cu	0.25	0.25	0.40	0.35	traces
Ag	0.49	0.53			
	100.61	100.27	98.70	99.83	99.60

Pb with 6 to 8% of As is worth 300f.
" 12 to 15% of Sb " 445f.

No. 4.—Treatment of Refining Crasses at Bleiberg.

Charge	8000k.
Refined in	48h.
Coal	600 to 700k.
Labor	4d.
Crasses yield in Pb	80%
Amount of erasses produeed.	11 to 12%

Pb produeed eontains.

Sb	2 to 3%
S	3%
Fe	0.15
Zn	traces.

No. 5.—Cost of Refining.

Labor,	.133	.33
Coal,	.80 at 1.6	1.28
Transportation,	.07 at 2.	.14
Sundries		.26
		2.00f.

No. 6.—Treatment of Refining Crasses at Freiberg.

Details of a Campaign.

Crasses eontain Pb	60 to 70%
Length of eampaign	179d.
Pb from the ore	1158.00t.
" mattes	110.25t.
" from oxydized produets.	710.
Total Pb	1978.25t.
Containing silver	7388.00k.

Obtained.

Hard antimonial or arsenical Pb 17.93t.
Refined silver Pb, containing 7291.795k. silver.....1779.25t.
Crasses with 60 to 70% Pb containing 154.177t. Pb and 91.477k. silver..... 217.95t.

Total, silver, 7384.265k. Pb 1951.357t.

No. 7.—*Quantity lost.*

Silver, 0.05% or.....3,789k.
Pb, 1.36% or 26,893

No. 8.—*Expense for Special Refining.*

Labor, { Founders, 371d... 677.00 / Laborers, 555d... 645.50
Fuel, { Bitum. coal, 150t ....1997.00 / Wood 1.20t. lignite 3.10t. 58.00
Blast engine..... 68.00
Repairs of furnaces & tools.... 395.50

3841.00f.

No. 9.—*Expense for Refining* 1*t.*

Labor, 0.455d.....0.668
Fuel, 0.075t 1.040
Blast engine.....0.034
Repairs of furnace & tools.....0.200

1.942

EXTRACTION OF SILVER.

No. 1.—*Treatment of Galena in a Reverberatory Furnace.*

2000k. of PbS at 74.04% Pb & 150g. Ag

% of Pb Extracted.	% of Ag Contained.	% of Pb Extracted.	%Ag Contained.
6.49	20.40	38.94	69.6
12.98	35.58	45.43	74.11
19.47	48.40	51.92	78.72
25.96	57.72	58.41	82.27
32.45	65.5	61.90	85.14

No. 2.—*Fractional Separation.*

Pb		Ag	Pb		Ag
100k.	with	471g.	600k.	with	368g.
200	"	411	700	"	244
300	"	370	800	"	227
400	"	333	900	"	210
500	"	304	1000	"	196

No. 3.—*Experiment in the Large Way.*

Wt. of ore. Yield in Pb Ag contains
50,000k. 74.413% 684g. per t.

	% Pb by wt.	Yield in Ag	% of Ag
1st time.	12.274	1600	26.729
2d "	12.399	1272	21.464
3d "	7.567	1054	10.850
We. crass	67.758	488	41.007
	100.00		100.00

No. 4.—*Value of the Lead.*

Pb produced. wt.	title.	Ag contained. grms.	value.	Cost extracting Ag	Increased value.
100	471	47.1	9.89	4.20	5.69
200	411	82.2	17.26	8.40	8.86
300	370	11.1	23.31	12.60	10.71
400	333	13.3	27.93	16.80	11.13
500	304	15.2	31.92	21.00	10.92
600	268	16.	33.60	25.20	8.40
700	244	17.	35.70	29.40	6.30
800	227	18.2	38.22	33.60	4.62
900	210	18.9	39.69	37.80	1.89
1000	196	19.6	41.16	42.00	0.00

No. 5.—*Separation of Gold.*

1st Ag contains Au 0.000949
2d " " " 0.000654
3d " " " 0.000511

METHOD BY PATTINSONAGE.

No. 1.—*Calculation for the Number of Boilers.*

M=quantity of Pb
P= " " poor Pb
R= " " rich Pb
a=yield of M in Ag
b= " P after n operations.
c= " R " n' "

$\frac{2}{3}$ M=P $\frac{1}{3}$ M=R
$\frac{7}{8}$ M=P $\frac{1}{8}$ M=R

For the relation $\frac{2}{3}$, P=0.62a. R=1.76a
For the relation $\frac{7}{8}$, P=0.714a. R=3a

After n′ operations,

$$Pn=(0.62)^{n}a=b$$

$$Rn'=(1.76)^{n'}a=e$$

Generally b=15 to 20g. the ton.
" e=7,500, 10,000 or 15,000grm.
At Stolberg a=200g., b=20g., e=10k.

The formula which is generally used for calculating the No. of operations is,

$$n=\frac{\log\frac{b}{a}}{\log p} \qquad n'=\frac{\log\frac{e}{a}}{\log q}$$

p=0.62 q=1.76
n=5. n′=7. n+n′=12

$b=(0.62)^{5}\times 200g.=18g.$ which is lost.
$e=(1.76)^{7}\times 200g.=10,460g.$ in rich Pb
If a=600, b=20g., e=7500g.
No. of operations for $\frac{2}{3}$ & $\frac{1}{3}$, 11 to 12.
" " " $\frac{7}{8}$ & $\frac{1}{8}$, 12 to 13.
If a=500 to 600, b=9, e=1500, Freiberg for $\frac{1}{3}$, n=11 to 12, n′=2, or 13 to 14 operations.
For $\frac{1}{8}$, n=16 to 17, n′=1, or 17 to 18 operations.

No. 2.—Skimmers.

Length of handle	3.20m.
Diameter of iron stem	0.045
" wooden "	0.095
Thickness of skimmer	0.015
Diameter "	0.40 to 0.50
Depth "	0.10 to 0.15
Capacity "	120 to 150k.
Diameter of holes	0.012
Distance between holes	0.002
No. of circles of holes	8 or 9

No. 3.—Molds for Pb.

	Poor.	Rich.
Length	0.90	0.30
Width	0.11	0.11

No. 4.—Details of the Boilers.

Height from ground	0.56
Diameter	1.70
Thickness at bottom	0.05
" " sides	0.03 to 0.04
Weight	1200k.
Cost	375f.
Old iron sold at 10f. the	100k.
Width of crown	0.32
Weight "	340k.

For details of the operations, see the Lithographic Plate.

9 boilers for 6t. require.

Common brick	150,000
Fire brick	10,000
Fire Clay	5t.

2 boilers can work 50t. per month. 15 to 20, with 18 men, can work 400t., if 25 working days are counted in a month.

No. 5.—Distribution of the Pb.

Poor Pb at 2g	448t.
Rich " 1041g	4t.
Pb of variable richness in boilers.	60t.
	512t.

No. 6.—Pure Pb at Stolberg.

For 1000.

Proof Pb at 17g		960.8k.
Rich "	176	16.7
Loss,	7	22.5
	200g	1000k.

Loss in Pb is 2.25%
Loss in Ag 7+17=24g.=1.2%
When the Pb is impure the loss is 3.5%

No. 7.—Law of Impoverishment.

Assays give the following results.

1	2	3	4	12	13	14	15
g.	g.	g.	g.	g.	g.	g.	g.
1,570	970	650	450	11	5	2.5	1.3

Relations of the sueeessive yields.

0.62–0.67–0.69.....0.45–0.50–0.52

$$1.3=1.570\times x^{14}$$

$$\log x=\frac{1}{14}\log\frac{1.3}{1.570}$$

x=0.60 nearly.

The Ag in the last erystalization at Freiberg is between 1.50 & 1.60k.

No. 8.—Composition of the Poor Pb.

	Pure.	Impure.
Cu	0.05 to 0.1	
Fe	0.02 "	0.5
Sb & As	0.02 "	0.1
	0.09 "	0.7% impurities.

No. 9.—*Expenses at Stolberg.*

(1.) Pattinsonage.

Coal, 133k. at 16	.....	2.13
Labor, 1d. " 2.33	.....	2.33
Wear and tear of boilers	.....	2.00
		6.46f.
(2) Cupellation of 16 to 17 of rich Pb at 50	.....	0.80
(3) Reduction of 200k. of crasses. For 1t.		
Coal, 150k. at 16	.....2.40	
Labor, 0.90	.....0.90	
Repairs, &c	.....1.00	
	4.30f.	0.86
(4) Refining Pb.		
Coal, 80 at 16	.....1.28	
Labor	.....0.40	
Repairs, &c	.....0.32	
	2.00f.	2.00
(5) Loss, 35k. at 500f	.....17.50	
		27.62
		17.80
		9.82f.

No. 10.—*Expenses at Bleiberg.*

Coal, 344 at 18.40	.....	6.31
Labor, { Skimmers, 2.75	..... }	5.12
{ Firemen, 6.8	..... }	
Revivification of 182k. of scoria	..	1.41
Wear & tear of boilers	.....	1.21
Sundries	.....	0.94
		14.99f.

No. 11.—*Expenses in England.*

Coal	.....	0.88
Labor	.....	11.91
Sundries	.....	.26
		13.05

No. 12.—*Work at Freiberg.*

Work at the boilers	..... 153d.
Sweating of the crasses	.... 22½d.
Salary of workmen, pr. basin	1.6872f.
No. of skimmings in 6 month,	5,712
No. of skimmings in a day	.. 37 to 38

No. 13—*Results at Freiberg.*

Employed for pattinsonage.

1779.25t. silver Pb from refining containing silver ..... 7291.795k.
301.16t. silver Pb from litharge containing silver ..... 140.250k.

Obtained.

1268.160t. commercial Pb
461.185t. rich silver Pb. 150gr. silver %k. consequently it contains 7006.190k Ag
393.150t crasses containing 377.000k. Ag and 339.796t. Pb

Recapitulation.

	Lead.	Silver.
Employed	2081.410t.	7432.045k.
Obtained	2069.140	7383.190
Lost	12.270t.	48.855k.
Loss %	0.59	0.657

Useful effect of the Crystalization.

Relation between the quality of poor & rich Pb obtained, and that really transported by the workmen.

$$\frac{1{,}729.345}{51.720} = \text{nearly } \frac{1}{30}$$

No. 14.—*Special Expenses for the Pattinsonage of* 2081.46*t. Silver Pb.*

Labor.

Men working at boilers 5.508d.	9639.00
Laborers for boilers 490d. wrk.	588.00
" for casting, cleaning carriage & wt. of Pb 964d.	1158.80
Founders for sweating, 108d.	146.00
Helpers, 230d. work	..... 276.00

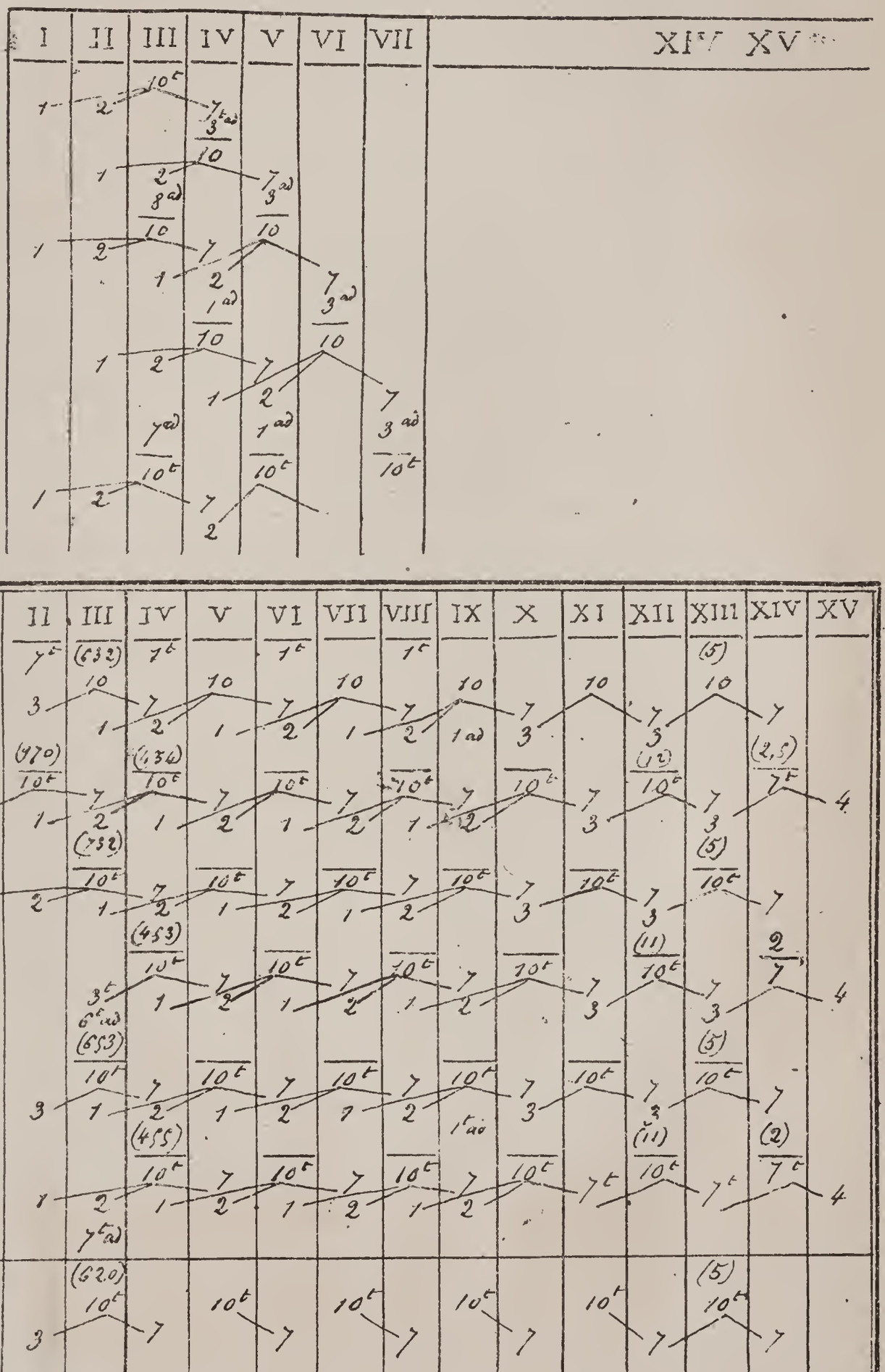
Fuel.

Coal for boilers, 815.5t	..... 10710.60
Coal for sweating 17.4t	..... 231.25
Lignite for basin, 45.4t	..... 705.50
Fine coal, 93.6t	.... 936.00

Repairs.

Labor on 12 boilers	... . 3054.50
Repairs to tools & furnaces	.. 300.00
	27743.65f.

Method by Thirds and Intermediate Cristallization (Freiberg.)



To face page 50.

Pattinsonnage. Method by Thirds.

Table showing the Skimmings from the commencement of the Operation to the production of Lead for Cupellation

Numbers of the Boilers: 1 2 3 4 5 6 7 8 9 10 11 12

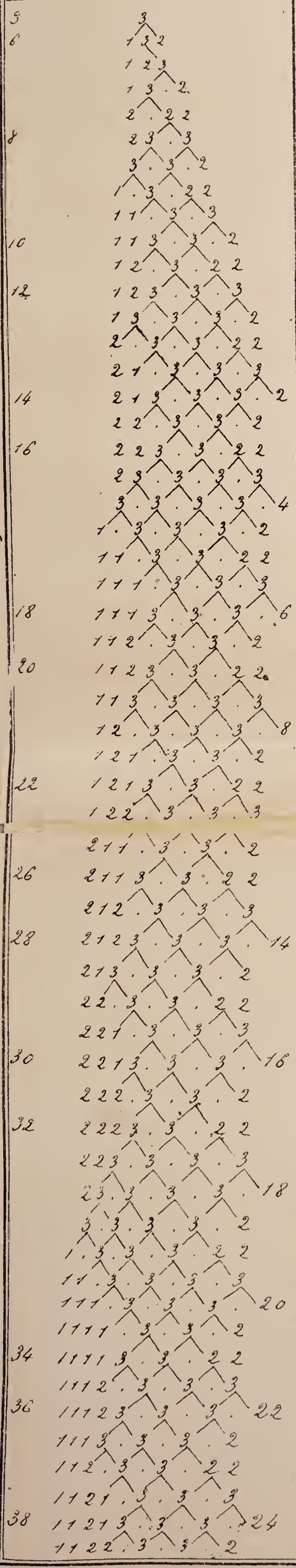


Table showing the Skimmings from the commencement of the Operation to the production of Lead for Cupellation

Numbers of the Boilers: 1 2 3 4 5 6 7 8 9 10 11 12

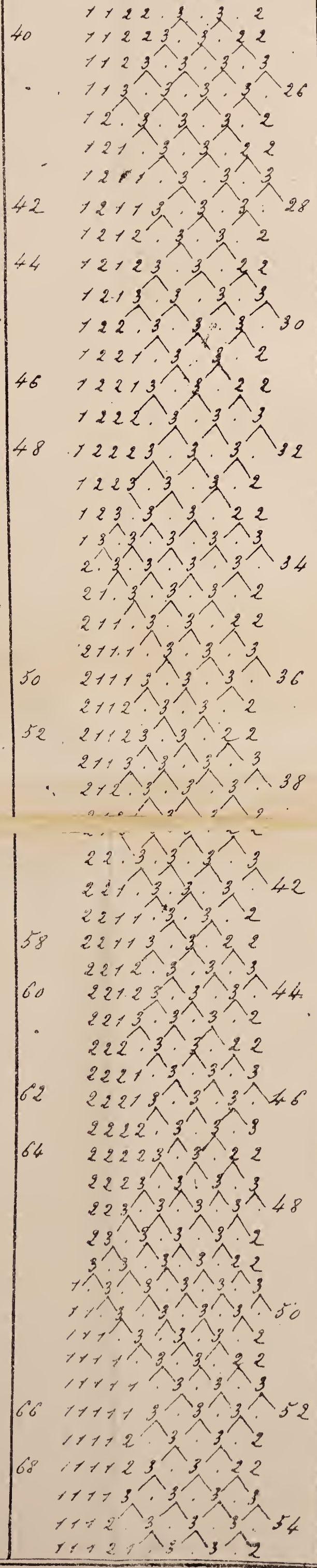


Table showing the Skimmings from the commencement of the Operation to the production of Lead for Cupellation

Numbers of the Boilers: 1 2 3 4 5 6 7 8 9 10 11 12

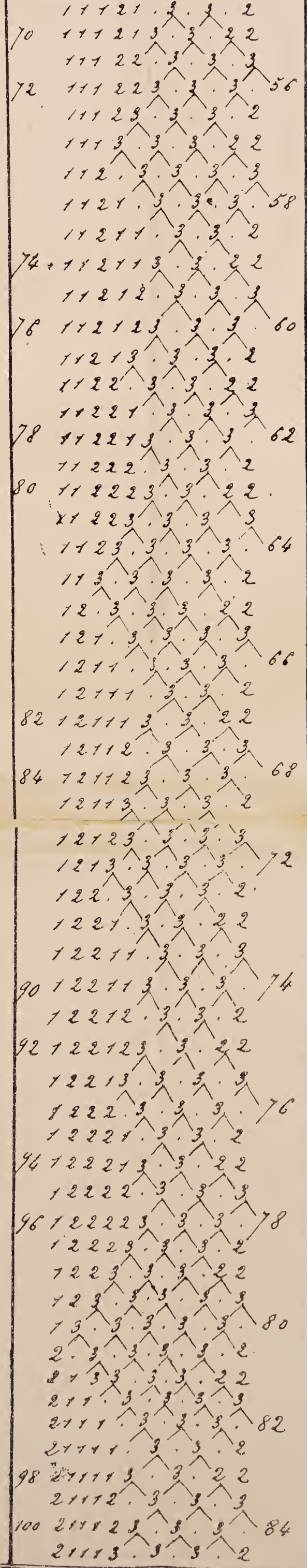


Table showing the Skimmings from the commencement of the Operation to the production of Lead for Cupellation

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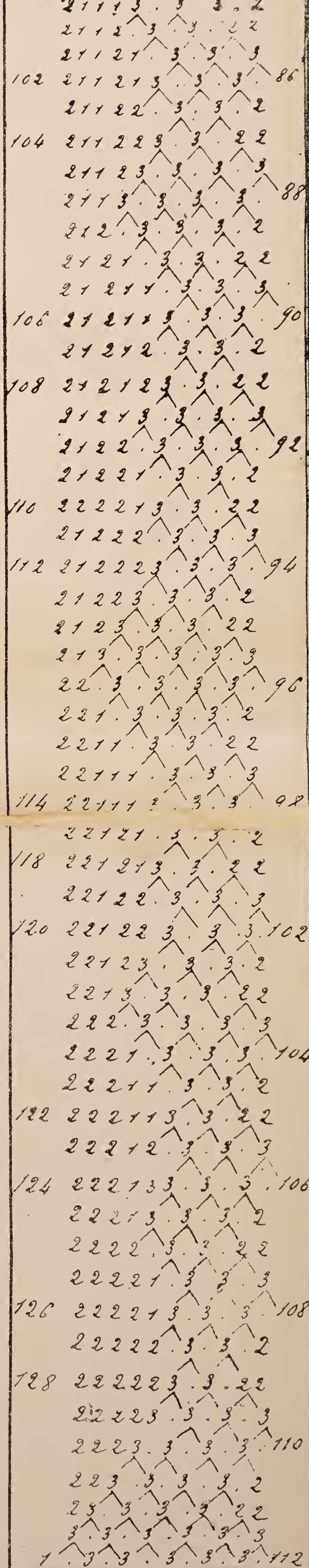

No. 15.—*Cost for the Pattinsonage of* 1*t. Silver Pb.*

Labor,	3.507d	5.670
Fuel, Bitum. coal,	0.406t.....	5.257
Fuel, Lignite,	0.022t.....	0.340
Fuel, Fine coal,	0.045t.....	0.450
Repairs		1.611
		13.328f.

No. 16.—*Comparison between Altenau and Freiberg.*

Altenau.

Pb from ore & matte for pattinsonage.....0.8 to 1% Sb
Skimmings in 24h. 4
4 skimmings cause the transportation of.....55t. Pb
Each boiler contains....11.250k. Pb
No. of boilers..... 13
No. men at battery by post 8
Average of silver in Pb for pattinsonage..... 240 to 250g.
Commercial Pb contains.2g. 5% arsenic.
Amount of silver in rich Pb after pattinsonage..... 580 to 600gr.
Time for crystalization & sweating of crasses at Altenau..... 42h.

Freiberg.

Time for crystalization & sweating crasses at Freiberg, 28h..3.507d.

Or if previously refined, less than 32h. These differences are owing to the methods of working and to the different kinds of fuel used.

CUPELLATION.

GERMAN METHOD.

No. 1.—*General Dimensions of the Furnaces.*

Diameter.....		2.40 to 3
Fireplace, Length.....		1 to 1.20
Fireplace, Width.....		0.50 to 0.55
Height of litharge hole....		0.60 to 0.70
Charge		8 to 10t.
Air per minute.....		0.05 to 0.10c.m.

Hearth.

Clay.....	1
Carbonate of lime.....	3 to 4
Thickness in centre.....	0.10
" border.....	0.20
Inclination	0.25

At Freiberg.

Greater axis of furnace.....	270
Smaller " "	250

At Viallas.

Diameter of the hearth....	2.30
Depth of " "	0.25 to 0.30
Greatest height roof above hearth	1 to 1.10
Width of fireplace	0.40 to 0.50
Length "	2.00
Grate below bridge.....	0.40 to 0.45
3 Openings for vapors.....	0.20 × 0.25
Flues " "	0.10 × 0.20

No. 2.—*Litharge.*

	Red.	Yellow.
Pb.....	98.17	97.81
Cu	0.11	0.09
Fe	0.08	0.12
Al	0.09	0.12
As & Sb.....	0.36	0.47
C	0.74	0.62
Residues.....	0.15	0.17
	99.80	99.40

No. 3.—*Litharge Mould.*

Length.....	0.70
Width.....	0.45
Depth.....	0.40
Weight of cake.....	750k.

No. 4.—*Time for the Operation at Viallas.*

Fusion.....	10h.
Production of abzugs.....	7
" " abstricks.....	6
Dirty litharges.....	2
Red & yellow litharges.....	28
Taking out Ag and cooling....	0.75
	53.75h.

In general	52 to 56h.
Taking out hearth	12
Breaking hearth, weighing Ag	8
	53 to 75h.
Pb oxydized in 1h	120 to 150k.

No. 5.—*Products for* 1*t. of Pb Cupelled at Viallas.*

Impure Ag	3.710k.
Red litharge	192
Yellow "	520
Dirty "	25
Fuel used	268

No. 6.—*Cost for* 1*t. of Pb Cupelled.*

Marl		6.00
Labor		5.21
Preparing litharges		0.42
Prime to workmen		1.71
Fuel, Cupellation,	0.268	5.64
Fuel, Engine,	0.200	4.30
Wear & tear of tools		0.71
" " furnace		0.34
Sundries		0.50
		24.83f.

No. 7.—*Products at Freiberg.*

Quantity of Pb cupelled	17t.
Abzugs	100t.
Red litharge at 5 to 7% of Ag to 100	1.5 to 3t.
Yellow litharge at 10 to 40% of Ag to 100	12 to 14t.
Debris cupellation at 60% Pb & 25% Ag	2 to 2.4t.
Ag at 96.5%	0.220 to 0.225t.
Length of operation	72h

No. 8.—*Expense at Freiberg.*

Labor, Cupelle		1.50
Labor, Laborers		1.25
Wood, per 1st. to 0.9 st.		0.30 to 0.33
Repairs furn. 20.90 pr 1t. Pb		1.23
" tools, 10.25 "		0.06

REFINING THE SILVER.

No. 1.—*Dimensions of Refining Furnace.*

Length of hearth	1.10
Width "	1
Fireplace	0.45 × 0.55
Height of arch above bridge	0.75
Diam. of tuyeres	0.018
Height of tuyeres to metal	0.025
Charge	1t.

No. 2.—*Length of Operation.*

Making hearth	3h.
Heating furnace	9
Fusion	2
Fining	8
Cooling & taking out cake	2
	24h.

Diam. of spoon for casting Ag	0.20
" cake of Ag	0.25
Weight " "	10k.
Title of the Ag	0.997
Cost of refining 1k. Ag	0.025f.
Coal for 1t. of Ag	600k.

No. 3.—*Separation of Bi*, 1862.

Cupel debris treated	1.136t.
Time	60d.
Days' labor	231
Coal used	5t.
HCl 3.015t. at	46.80
Total expenses	655f.

Obtained.

Refined Bi	192k.
Sold at 15f. for 1k.	2,080f.
Residue at 40% Pb & 4.162% Ag	106k.

No. 4.—*Expenses in the Hartz.*

1t. Pb gives Pb 960 & Ag 1.25g.

		Pb
Poor litharge,	666 at 90%	599
Rich "	122 at 88%	107
Abzugs & abstricks	100 at 83%	83
Cupel bottoms,	133 at 70%	93
Ag,	1.25	
	1022.25	822k.
Marl for hearth,	33 Loss in Pb,	78
	9.89	900

960 of Pb corresponds to 1034 litharge.
38.70 of foreign metals 50 of "

There should be of oxydes	1084
There are only	988
Loss by volatilization,	96
78k. of Pb volatilized gives	84 litharge.
	12k.

12k. is too small, 78k. is too large.

No. 5.—For 1t.

Labor, 180	3.20
Fuel, 340 at 17	5.87
Marl & repairs	3.52
	12.50
Value of Pb lost	45 to 50
	57.5 to 62.50
General expense	17.5 to 12.50
	75.0 75.00

No. 6.—Expenses at Tarnowitz.

1t. Pb gives Pb 992 & Ag 200g.

Poor litharge,	889	at 92%	818
Abstricks & abzugs	21	" 85%	18
Cupel bottoms,	180	" 65%	117
Ag,	0.5		
	1090.5	Pb & Ag	953
Marl of hearth,	54	Loss of Pb	39
	1036.5		992

992 of Pb corresponds to 1069 litharge.
7.5 of foreign metals, 10 oxydes.

1079
Oxydes obtained, 1036

43
39 Pb volat'zd corresponds 42 litharge.

1

No. 7.—General Resumé.

Labor eupellation & revivification			2.80f.
Coal	eupella'n, 225 / revivifica'n, 67	272 at 10f.	2.92
Marl & repairs			1.50
Loss of 45k. at 500f			22.50
			29.72f.

Pb with 15 to 18g. may therefore be cupelled.

No. 8.—Treatment at Freiberg.

Employed for extraction of silver.

	Silver.
461.185t. Pb fr patin'ge, cont.	7006.190k.
225.400t. " smelt'g rich ore,	1741.000k.
0.304t. silver ore (pure ore) containing	199.202k.
686.889t.	8946.392k.

No. 9.—Products Obtained.

81.050t. red commercial lith.

	Pb	Ag
	76.585t.	
10.950t. abzugs.	7.675t.	18.925k.
550.500t. lith. redu.	478.935t.	160.215k.
70.400t. cupel bot.	42.240t.	17.600k.
9046.63k. cake Ag .967		
Cake refined produces:		
8753.76k. refin'd Ag 9.972		8729.312k.
0.381t. cupel bottoms		6.820k.
Total,	605.43ft.	8932.872k.

No. 10.—Loss of Metals.

Silver, 14.520k. or 0.162% of the metal contained in the ore.

Pb, 81.150t. or 11.82% of the weight of the alloy cupelled, if the Ag contained in the alloy is deducted.

Loss of Pb=72.20t. or 10.65% of metal contained in the alloy.

The extraction of Ag has required

Number of eupellations	41
Time for all the eupellations.	2764h.
" one "	67 to 68h.

The revivifying the Ag has taken 8 campaigns of 12h. each.

No. 11.—Expense for these Two Operations.

1st for the Cupellation.

Labor.	Cupell'rs 336 posts, 8h.	1020.90f.
	Helpers, " "	850.75
	Primes for 86t. red lith.	43.00
	Laborers for transportation, 276d	331.20
Fuel.	Wood, 128t.	3156.50
	Shavings, 16.7t.	167.00
Blast engine		199.00
Repairs of furnace & tools		900.00
		6668.35f.

2d for refining Silver.

Labor		223.00f.
Fuel.	Coal, 9.9t.	134.10
	Charcoal, 0.13t	17.10
Repairs		49.50
		423.70f.

No. 12.—*Expense for both Operations on* 1*t.*

Labor, 1.330d		3.595f.
Fuel.	Wood, 0.211t.	4.838
	Coal & charcoal, 0.013t.	0.220
Blast engine		0.289
Repairs of furnaces & tools		1.383
		10.325f.

ENGLISH CUPELLATION.

No. 1.—*Details of English Cupel Furnace.*

Fireplace	0.60 × 0.75m.
Width bridge	0.45
Height of oval ring	0.12
Major axis of "	1.20
Minor " "	0.90
Size of bottom bars	0.11 × 0.012
Fuel used for 1t. rich Pb	4quint.
Pressure of blast, 0.01 to 0.015m. of Hg	
No. common brick for construction	2000
" fire brick	2000
Fire clay	1.500t.

No. 2.—*Cost in England, (Newcastle.)*

Labor		5.26
Coal, 4 quint		.714
Engine.	Labor	2.00
	Fuel	.914
Ashes for cupel		.367
Bone ash		3.883
Repairs		.52
		13.658f.

No. 3.—*Cost in General.*

Coal, 1.50 at 7.50	1.12
Labor, 1.5 at 1.20	4.20
Accessories	2.00
Loss Pb 76k. at 500	35.00
Cost of purifying litharges	4.50
	46.82f.

No. 4.—*Details of Production of* 1*t. of Ore.*

1t. ore produces roasted ore	850k.
" " Hard Pb	420
Soft Pb	360
Rich Pb	99
Crasses & litharges.	18.5

SEPARATION OF SILVER BY ZINC.

REDUCTION OF THE LITHARGES, &c.

TREATMENT IN REVERBERATORY FURNACE.

No. 1.—*England.*

Length hearth	2.40m.
Width "	1.50
Pb produced in 24h	4500k.
Fuel used "	1000k.
No. of men	2
Cost for 1t. litharges	10f.

No. 2.—*Expenses in North England.*

Coal, 150 at 16f.		2.40
Labor, 0.33"	2.50	0.83
Repairs		0.79
		4.00f.

Labor	3.20
Coal	0.55
Repairs	0.17
	3.92f.

No. 3.—*Expenses at Viallas.*

Charcoal,	83k. at 46f.	4.98
Coal,	117 " 21.50	2.51
Labor,	0.75 " 1.75	1.31
Repairs		0.25
		9.05f.

No. 4.—Belgium.

1000k. litharges produce Pb	804.40
Crasses at 48%	211.30
Quantity treated in 24h	5 to 6t.
Fuel per 1t	325k.
Direct yield	80.44%
Total yield	90.80%

No. 5.—Refining Furnace.

1000k. litharge produees Pb	787
Residues at 52%	250
Fuel used	344k.
Total yield	91.7%
Quantity in 24h	1500 to 1600
Cost of revivification	6.50f.

TREATMENT IN A SHAFT FURNACE.

No. 1.—Silesia.

Height of furnaee	1.50m.
Quantity reduced in 24h	15t.
Pb produeed	88%
Crasses produeed at	12%
Pb extracted from erasses	3%

No. 2.—Hartz.

Scorias against tuyere	10k.
Chareoal " breast	12.5k.
Litharge in baek corners	87.0k.
Campaign lasts	56 to 63h.
" works	82.800k.
In 24 hours' charge	30.000
Chareoal	11%
Cost per ton litharge	10f.
Losses in Pb	2%

No. 3.—Furnace at Freiberg.

Pb to be refined.

Height furnaee	2.28m.
Quantity treated in 24h	45t.
Product eontains Pb	90%
No. tappings	20
Men for 24h	8

Pb not to be refined.

Height of furnaee	2.28
No. of men	5
Litharge treated in 24h	25t.

Litharge from the last part of cupellation.

Quantity litharge for 24h	15t.
Old seorias	10%
Scorias of revivification cont'n	25.30% Pb

No. 4.—Working Scorias

Quantity treated	100
Pyrites added	3
Work in 24h	5t.
Seorias produeed eontain	3% Pb

No. 5.—Treatment of Abstricks.

Puddling seorias	24%
Seoria from same operation.	30 to 40%
Pb produeed contains Sb.	18 to 24%
Seoria & debris contain Pb.	12 to 14%
Loss by volatilization	5.65%

No. 6.—Treatment of Patinsonage Crasses.

Stolberg.

Crasses with Pb	90 to 95%
Charges in 24h	10t.
Fuel used	15 to 20%
No. of men	2

Altenau.

The 100k. of Pb produee.

Rich erasses wh. go to cupell'n	17.29%
Poor " " revivifi'n	16.35%
Loss in poor crasses	12 to 13%
Loss of Pb contained	2.012%
Yield of erasses in furnace	90 to 96%

No. 7.—Details of Operation.

	Pb	Ag
1224.25t. pre'g op.	1022.822t.	665.218k.
111.525t. " "	68.195t.	110.530k.
50t. of old seorias	1.300t.	40. k.
18.4t. of ore as flux	2.655t.	1.895k.
1404.21 eh. cont.,	1094.212t.	782.395k.

Obtained.

	Pb	Ag	Cu
Pb for refining 720t.		653k.	
" patin'ge 302.16		140.25k.	
Matte, 37.875 15.50		11.362k.	6.222t.
Seorias, 271.405 3%			
1321t. prod. eontain	1035.452t.	804.612k.	6.222t.
Loss in Pb	58.760t. or 5.37%		
Exeess Ag over Assay	22.217k. or 2.84%		

No. 8.—*Expenses.*

Roasting, 22d	33.00
Smelters & chargers, 1268d	2282.00f.
Laborers, 47d	56.4
Coal for roasting 27t	.36f.
Charcoal for fusion 182t	.4368.00
Stamping 205t. of matte	18.25
Blast engine	248.65
Repairs to furn. & tools	291.60
	7334.00f.

For 1t. of charge.

Labor, 0.952	1.688f.
Coal, 0.002	0.026
Coke, 0.129	3.111
Blast engine & stamps	0.190
Repairs to furnace & tools	0.028
	5.223f.

No. 9.—*Recapitulation.*

For refining.

Silver Pb	1268.25t.
From revivification	710.00t.

For pattinsonage.

Refined Pb	1779.41
Pb from revivification	302.16

For cupellation.

From patinsonage	461.185t.
Pb from rich ore	225.40t.
Pb from Ag ore used	0.3043t.

For revivification.

Oxydes & scorias	1404.00

All this material contains,

Ag	8792.437k.
Pb	1565.040t.

No. 10.—*Products Obtained.*

Pb with As & Sb	17.930t.
Pure Pb	1268.160t.
Red litharge	81.050t.
Matte	37.870t.
Scorias with 3% of Pb	271.405
Refined Ag	.875,376t.
Debris of cupellation	.381t.

These materials contain.

Ag	8747.494k.
Pb	1385.945t.

Loss.

Ag, 44.943k. or	0.511%
Pb, 179.073t. or	11.442%

No. 11.—*Cost of all the Operations.*

Fining Pb.

Labor, 0.592	0.884
Fuel, 0.099t	1.373
Blast engine	0.045
Repairs to tools & furnaces	0.265
	2.571

Pattinsonage.

Labor, 4.885d.	7.898f.
Coal, 0.565t.	7.323
Lignite, 0.031t	0.474
Fine coal, 0.063t	0.672
Repairs to furnaces & tools	2.244
	18.566f.

Cupellation & Refining Ag.

Labor, 0.687d	1.650f.
Wood, 0.096t	2.222
Coal, 0.059t	0.101
Blast engine	0.132
Repairs to furnace & tools	0.634
	4.739f.

Revivification of litharges, &c.

Labor, 0.894	1.587
Coal, 0.002	0.024
Coke, 0.122	2.925
Blast engine, stamps, &c	0.179
Repairs to furnace & tools	0.195
	4.910

No. 12.—*Total Cost of* 1*t. of Pb.*

Labor, 7.056	12.019
Coal, 0.756	9.299
Coke, 0.185	3.552
Wood, 0.096	2.222
Blast & stamps	0.356
Repairs to furnace & tools	3.338
Cost for 1t. silver Pb	30.786f.

No. 13.—*Loss.*

	Ag	Pb
For 1t. silver Pb	30g.	120k.
Average price metals, 1862.	222.5	435
Price of material lost	6.67f.	52.20f.
Total loss	58.87	
Cost of treatment	30.79	
Excess loss above cost	28.08	

CONDENSATION OF VOLATILE PRODUCTS.

No. 1.—*Experiments at Corphalie.*

	Length	Interior volume.	Friction surface.	Height chim'y.	Useful effect.
	m.	c.m.	s.m.	m.	%
Old conduit	819	1815	4765	100	15.35
New "	995	2826	7609	100	25.95

No. 2.—*Ratio between the No. of Kil. Condensed & Condensible.*

Malden.

Length of canal.....180m.
Capacity of 1st chamber.....849c.m.
" 2d " .... 1482c.m.
" 3d " .... 6330c.m.
Chimney connecting 1 & 2.... 46m.
" " 2 & 3.... 37m.
Chimney of general delivery.. 61m.

No. 3.—*Quantity of* S̈ *in Vapors.*

Vapors of fusion furn.	$\frac{1}{500}$ to $\frac{1}{700}$ vol.
" roasting stall.	$\frac{1}{250}$ "
" muffle	$\frac{1}{160}$ "
At 10m. frm chimneys.	$\frac{1}{50000}$
60 to 70...	$\frac{1}{90000}$
With a wind..... ..	$\frac{1}{150000}$
At 100m.....	$\frac{1}{1000000}$
Quantity necessary to injure vegetation.	$\frac{1}{80000}$

No. 4.—*Volatile Products at Alston Moor.*

Ṗ	10.2
ṖbS̈	65.6
F̈e	3.4
Żn	13.8
PbS	1.4
S̈i	5.6

No. 5—*Volatile Products at Pontgibaud.*

	Outside deposit.	1st condensation arch.	Ventilation chamber.
Ṗb	10.0	66.5	3.7
ṖbS̈	47.0		13.0
Pb			55.4
Äs		1.1	1.5
F̈e		3.0	13.0
Żn	10.0	12.0	3.1
S			8.9
S̈	33.0	17.0	

No. 6.—*Volatile Products of Roasting Furnace at Pontgibaud.*

	1	2
Ṗb	11.0	
ṖbS̈	60.0	39.0
Äs	2.0	1.5
F̈e	12.0	1.5
Żn	15.0	2.7
ṖbC̈	15.0	35.0
ŻnS̈	15.0	2.3
PbS	15.0	4.5
S̈	15.0	13.2

No. 7.—*Volatile Products at Clausthal.*

Ṗb	18.0
ṖbS̈	2.9
Pb	35.8
Fe	1.0
Sb & As	0.5
Zn	1.0
F̈e	4.5
Żn	1.5
S	7.8
S̈ Äs	2.5
C̈ & O	7.7
C	2.5
ḂaS̈	12.3

No. 8.—*Agglomeration.*

Quantity treated.....34,700k.
Fuel used.....9400k.
Labor ..... 28d.
Cost ..... 6.25f.
Quantity in 24h. 2,000 to 2,500k.
" agglomerated material produced 27,211k.
Loss in Pb, Shaft furn. .10.8%
" " Rev.....11.67%
Cost of fusion..... 14.47

Making bricks per ton.

Labor ..... .75
Lime, 0.45c.m. at 7.50 ..... 3.37
4.12

1000k. make of bricks 1400k.

Treatment.

Coke, 20%
Forged scorias 74%
Cost of fusion 27.25

31.49
Cost of agglomeration 17.09

13.88

No. 9.—*Agglomerated Volatile Products at Conflans.*

Ṗb	42.6
ṖbS̈	39.0
S̈i	17.4

No. 10.—*Agglomeration in Rev. Furn.*

Quantity treated ..... 67,565k.
Fuel used ..... 18,000k.
Labor ..... 60d.
Cost 6.25
Quantity in 24h 4500
Material produced ..... 52,365k.
Contain Pb 44.25%
Agglomerated prod'ts cont. Pb 53%
Loss in weight 23%
Loss in Pb charged 3.25%
Pb condensed ..... 7.7 %

No. 11.—*Treatment in Shaft Furnace.*

Puddled scoria 35%
Coke 15%
Scorias containing Pb ..... 1 to 2%

No. 12.—*Volatile Products at Freiberg.*

Ṗb	27.9
ṖbS̈	13.0
Ȧs	2.1
Żn	49.5
Co	7.0

No. 13.—*Condensation of the Volatile Products at Freiberg.*

In 1h. an English roasting furn. produces 25k. of sulphur, corresponding to 50k. of sulphuric acid.

To saturate 50k. of S̈ requires 44k. of lime or 350 litres of lime water.

Theoretically to saturate 1200k. of S̈ in 24h. requires

BaS̈ ..... 2,950k.
Ḃa S ..... 2,100k.
Litres of water 11,950

In practice.

BaS̈ ..... 4,500k.
Litres of water 30,000

No. 14.—*Apparatus for Condensation.*

(2 buildings.)

Each building contains 6 galleries.

Height of the canal ..... 2.50m.
Width " ..... 1.50m.
No. of galleries juxtaposed 6
Height of each gallery ..... 4 m.
Width " ..... 1.10m.
Length of all the galleries ..... 75 m.

No. 15.—*Product of* 3 *Months.* (1863.)

Arsenical fumes ..... 72t.
Containing Ag ..... 8g.
Pb 3.5%

No. 16.—*Apparatus for Condensation at Halsbrücke.*

Width of gallery ..... 1.42m.
Height " ..... 2.30m.
Width near chimney ..... 5.70m.

TREATMENT OF ORES OF SILVER.

1. FUSION WITH LEAD, OR LEAD ORES.
2. AMALGAMATION.
3. TREATMENT IN THE WET WAY.

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1. FUSION OF LEAD ORES AT FREIBERG.

TREATMENT.

(1.) Roasting.
(2.) (*a*) Fusion of Ores.
(*b*) Concentration of mattes.
(*c*) Treatment of Scorias.
Shaft Furnace.
Reverberatory Furnace.
(3.) Treatment of the Lead Mattes.
(*a*) 1st Fusion.
(*b*) 2d Fusion.
(*c*) Treatment of Scorias.

(1.) ROASTING.

No. 1.—*Methods of Roasting.*

Rectangular Pile.

Height ..... 1.50m.
Width at base ..... 2m.
Used for pyritiferous ores & scoria matte.

Wellner's pile.

Height of chimney from 2.30 to 2.50m.
Diameter " 0.40
Quantity of ore ..... 30 to 50t.
Used for pyritiferous ore & scoria mattes.

Wellner's stall.

Bottom, { Length .....3.70m.
{ Inclination ..... $\frac{1}{10}$
Thickness of the wall 0.80
Dimensions of ore, 3 or 4cen. in diam.
" matte, 4 or 6 " "
Time for lighting fire ..... 13 to 16h.
Capacity of the stall ..... 45 to 60t.
Time of roasting ..... 8 to 10w.
S remaining after roasting ... 8 to 10%
Used for pyritiferous ores & scoria matte.

Kilns.

Height ..... 1.50m.
Upper base .....1.
Lower " 0.50
Used for pyritiferous ore in pieces, or for fine or agglomerated ores when S is made.

No. 2.—*Details of Roasting* (1862.)

Length of campaign ..... 182d.
Ore treated ..... 772t.
Labor (days of 8h.) ..... 618d.
Shavings & wood ..... 50c.m.

No. 3.—*Cost for Roasting* 1*t.*

Shavings for fire ..... 0.66m.
Days' work 0.80
Cost ..... 1.24f.

No. 4.—*Cost for the Agglomeration in Bricks.*

Bitum. & fine coal, 0.184t..... 1.98
Sulphuric acid (66°) 0.022t. at 50f. 1.10
Calcareous marl, 0.044t. " 15f. 0.66

Labor.

4.83d. for agglomeration, at 1f.. 4.83
0.11d. transportation at 1.20.... 0.13

Cost ..... 8.70f.

No. 5.—*Roasting in Reverberatory Furnaces with* 1 *Hearth.*

Used for fine ores & pulverized mattes.

Hungarian Furnaces.

Hearth, { length .....2.85m.
{ width .....2.

English Furnaces.

Hearth, { length .....4.57m.
{ width .....4.
Height of arch in the middle....0.47
" " at side 0.28
Charge of the furnace .....1000k.

No. 6.—*Quantity of Ore Roasted by* 2 *Workmen in* 8*h.*

Ordinary Pb ore ..... 1234k.
Ore containing Cu or Blende .. 1000k.

Fuel consumed in 24h.

Bitum. coal ..... 0.9t.
Or, { Bitum. coal 0.50
{ fine coal 0.45

No. 7.—Expense for Roasting 1t. in Reverberatory Furnace.

Labor, 2.133d	3.20f.
Fuel, 0.252t	3.20
Repairs of furnace & tools	1.00
Cost	7.40f.

No. 8.—Reverberatory Furnace with 2 Hearths.

Used only for lead ores.

Fireplace	1.30m. × 0.50m.
Hearths	2.85 × 1.37
Upper hearth	1.71 × 3.61
Height of lower hearth	0.57
" " upper "	0.35
Partition between 2 furnaces	0.14
Door of the lower hearth, height	0.25
Door of the lower hearth, width	0.15

Gas from muffle contains 1% of S

Lead ore.

Charge	500 to 550k.
Thickness of bed	0.05 to 0.06m.
Time in furnace	4 to 4¾h.
Coal consumed in 24h	650k.
Sulphur in ore after roasting, 4.5 most.	
Pay of men for 8h	1.50f.

Shape of the Rable.

Length	0.12m.
Width	0.08
Length of iron rod	8
" " wooden handle	1

No. 9.—Cost for Roasting.

	For 4.379t.	For 1t.
Labor, 9.490 at 1.50f.	14235.00f.	3.27f.
Fuel, coal, 858.42t.	11464.00	2.93f.
Fuel, lignite, 86.00t.	1336.45	
Repairs furn. & tools,	2272.00	0.52f.
	29507.45f.	6.72f.

(*a*) FUSION OF ORES.

No. 1.—Double Furnaces for Fusion of Pb Ore.

	m.
Height from throat to tuyere.	4
" " tuyere to crucible	0.43
Width at the tuyeres	1.71
" at rustine	1.14
Depth	1.21
Dimensions at the throat.	0.74–0.57–0.86
Distance between tuyeres	0.71
Pressure of blast	0.026m.Hg

No. 2.—Charge.

Ore	100%
Roasted matte	50%
Fluor	4%
Scoria containing Pb, crasses, &c.	150%
Coke consumed for 100 ore.	46 to 50%
Box for charging contains	28 to 29k.
Basket for coke "	10k.
Regular length of nose	0.10 to 0.15m

Alternate charge.

1 basket coke.	1 basket coke.
2 boxes of charge.	4 boxes of charge.

Volume of air=4½ to 5c.m. in 1 minute.

No. 3.—Work in 24h.

Good working.

Ore	3000k.
Roasted matte	1500k.
Scorias	4500 to 5000k.
	9000 to 9500k.
Coke	1400k.

But often :

Ore	2 or 2½t.
Roasted matte	1 or 1¼t.

Workmen for a double furnace.

Workmen.	No. of work.	Time	Salary.
Founder,	1	12h.	0.50f. for 100k. ore.
Filler,	1	"	"
Cinderman,	1	"	"

No 4.—Products in 24h.

Silver Pb	800 to 1050k.
Matte	400 to 500 k.
No. of tappings in 24h	4
Wt. of the pig Pb	15 to 16k.

No. 5.—*Analysis of Scorias.*

	Mulde.		Halsbrucke.	
Si	29.738	27.05	26.742	28.14
Al	0.210	6.85	3.164	5.78
Fe	49.104	41.21	39.937	37.23
Mn	2.120	0.90	3.571	0.63
Mg	0.127		1.053	
Ca	5.660	8.84	5.458	7.68
Ba				3.87
Pb	4.685	3.90	4.736	7.35
Zn	7.602	8.62	13.235	7.60
Cu	0.516	1.00	0.937	0.50
S	1.956	3.53	3.782	2.47
A			0.096	
Total,	101.718	101.90	102.611	101.25
Oxygen for sulph.	0.978	1.76	1.891	1.23
	100.740	101.14	100.720	100.02

No. 6.—*Analysis of Scorias.*

	Common working of.		Very quick descent the charges.	
	1	2	1	2
Si	28.54	30.5	35.16	43.26
Al	5.4	5.1	1.06	3.2
Ca	8.31		5.96	5.41
Mg	traces.			0.71
Fe	46.1	55.74	38.25	33.15
Mn		2.2		
Pb	4.12	4.0	7.11	5.64
Ba	1.0			
Zn	3.1	0.85	8.06	7.83
Cu	traces.		0.73	0.61
S	1.00		3.30	0.32
S	2.43			

No. 7.—*Average of the Amount of Metals in* 100*k. of Scorias.*

Ag ..... 29.04 g.
Pb ..... 4.916k.
Cu ..... 0.403k.

(*b*) CONCENTRATION OF THE MATTES.

No. 1.—*Fusion of the Mattes.*

Proportion.

Mattes 1
Scorias 4
Castings in 24h ..... 7 to 9

No. 2.—*General Composition of the Matte.*

S	18%
Fe	37%
Pb	31%
Cu	5%
Ag	140gr.

No. 3.—*Analysis of the Matte.*

	Mulde.	Halsbrücke.
S,	19.852	22.847
Pb,	23.283	21.816
Fe,	36.017	37.202
Cu,	15.277	12.944
Ni, Co,	2.329	0.544
Zn,	0.136	1.439
Ag,	0.121	0.099
As,	1.248	0.731
Sb,	0.849	0.718
	98.912	98.340

No. 4.—*Analysis of the Mattes.*

	Matte not repassed.	Matte. repassed	Matte concentrated for copper.
Pb	31.10	20.25	24.8
Fe	37.47	27.05	15.2
Cu	4.81	27.614	36.2
Zn	2.75	0.231	
Ag	0.14	0.117	0.16
As	1.28	0.650	
Sb	1.00	1.005	
S	17.55	21.314	21.00
C	1.2		
Ni	1.96	1.01	2.64

No. 5.—*Results.*

Employed.	Wt.	Ag	Containing Pb	Cu
Lead ore,	3680 t.			
Poor ore	669.5t.	6880.45k.	1569.66t.	1.99t.
Ore containing Cu	25.5t.			
Total of ore	4375.00t.			
Roasted matte	2122t.	2865k.	106t.	42.44t.
Materials volatilized in roast'g.	21t.			
Crasses	6t.			
Obtained.				
Rich silver Pb	225.40t.	772.4g.		
Ordinary silver Pb	1158.00t.	521.9g.		
Total	1383.40t.	7785k.		
Matte containing Pb	206.05t.	250g.	25%	12%
Speiss containing Ag	3.50t.	50g.		2%
Scorias	4897.3t.	1422k.	240.60t.	19.74t.
		9724.00k.	1675.50t.	44.40t.

No. 6.—*Recapitulation.*

	Ag	Pb	Cu
Employed,	9745.85k.	1676.46t.	44.43t.
Obtained,	9724.00	1675.50	44.40

No. 7.—*Expenses for this Operation.*

Fluor	19.45t.
Coke	2016.00t.
Coal	123t.
Charcoal	16c.m.
Workmen, 1st class	12.443d.
" 2d "	4.541d.

No. 8.—*Cost of this Operation.*

(2d 6 months 1862.)

Labor.	
Inspector, 129d. at 2.25f.	290f.
Founders & fillers, 11434d.	21,876
Matte roasters, 880d. at 1.50f.	1,320
Laborers, 3964d. at 1.20f.	4,737
Fuel.	
Ordinary coke, 1569t. at 24f.	37,656
Gas Coke, 447t. at 18f.	8,046
Charcoal, 2.4t	240
Coal, 123t	1.441
Flux, fluor, 19.45t. at 17.70f.	345
Blast engine	2,242
Stamping the matte	1,420
Repairs of furnaces & tools	5,777
	85,390f.

No. 9.—*Cost of the Operation for* 1*t. of Charge.*

Labor,	Inspect. & found., 1.778d.	3.415f.
	roasters, 0.136d. at 1.50f.	0.204
	laborers, 0.612d. at 1.20f.	0.734
Fuel,	coke, 0.310t. char'l, 0.36k.	7.075
	coal for roasting, 0.119t.	0.222
Flux, 0.003t., Fluor, 17.70t.		0.005
Blast engine & stamps		0.566
Repairs of furnaces & tools		0.891
		13.160f.

(*c*) TREATMENT OF SCORIAS.

No. 1.—*Furnace for Fusion.*

Fireplace	1.05 × 1.05
Bridge	1.05 × 0.71
Distance fr bridge to hearth.	0.28
" " grate.	0.66
" grate to ash-pit.	1.56
Dimensions of hearth	3.70 × 2.29
Inclination "	0.14
Width of working door	0.38m.
Height of chimney	17m.

Composition of the hearth.

Siliceous scorias	1
Quartz	5

No. 2.—Charge.

Ore & scoria cont'ng Pb..750k.
Roasted ore.....400 to 450k.
Ore not roasted.....300 to 350k.

Dimensions of the rable.

0.20m. × 0.06m. × 0.08m.

Discs of mattes.....220 to 230k.

Charge for 24h.

7 charges of 750k. ore..... 5250k.
Scorias containing Pb..... 5250k.
Coal, (¾ 2d quality)....5500 to 5600k.

Each furnace produces, in 24h., 2500k. mattes.

No. 3.—Assay of the Matte, (1862.)

Ag,	135gr.
Pb	5%
Cu,	2%

No. 4.—Analysis of the Matte.

S	26.702	23.43
As & Sb	0.240	0.84
Fe	57.781	53.81
Pb	4.996	7.35
Cu	4.416	3.87
Zn	2.618	7.65
Ni	1.312	
Si		2.11
Ag	0.086	
	98.151	99.06

No. 5.—Analysis of Scorias.

Si	34.30	36.68
Al	4.65	4.55
Fe	41.96	42.12
Ca	7.45	2.17
Mg & Mn	1.30	0.65
Cu	0.15	0.32
Pb	0.98	1.94
Zn	7.75	7.30
S		2.85
	98.54	98.58

Scoria contains,

Ag,	0.507g.
Pb,	1.5189%

No. 6.—Ore Treated.

	Wt.	Ag	Cu
Poor ore,	2257.18t.	50.5g	
Ore cont'g Cu	144.98t.	45.6g	1.1%
Ore as flux,	2854.15t.	15.6g	0.007%
	5256.31t.		

No. 7.—Products of the Treatment.

		Containing.		
Employed.	Wt.	Ag	Pb	Cu
Scorias containing Pb.....	4897.05t.	1422k.	240.53t.	19.74t.
Ore.....	5256.3t.	1655.92k.		2.30t.
		3077.92k.	240.53t.	22.04t.
Obtained.				
Matte.....	2320t.	3034k.	112.15t.	46.40
Poor scoria.....	7957t.	40.34k.	120.85t.	
		3074.34k.	233.00t.	46.40

Ag lost in the scoria..... 1.3% or 40.34k.
Pb " " ..... 50.3% or 120.85t.

No. 8.—*Cost for Roasting for* 6 *months.*

Ore in reverberatory furnace.		2043.14t.
Ore in stalls and kilns.		376.16t.
		2419.30t.
Labor,	roast's, 4661d. at 1.50f.	6991.50f
	labor's 675d. at 1.20f.	810.00
Fuel,	coal, 504.42t.	7035.75
	shavings & wood, 9t.	90.00
Repairs of furnaces & tools		1778.00
		14927.25f

No. 9.—*Cost for Roasting* 1*t. of Ore.*

Labor, 2.205d		3.266f.
Fuel,	coal, 0.208t	2.908
	shavings & wood, 0.0037	0.037
Repairs of furnaces & tools		0.520
		6.731f.

No. 10.—*Time for Smelting.*

Scorias, 4897.5t. } 1.014d.
Ores, 5256.3t. }
Including 30 days for repairs.

No. 11.—*Cost of Smelting.*

Labor,	founders, 8.096d.	14.720f.
	laborers, 5.214d.	6.257
	assistants, 2.083d.	2.500
Fuel,	coal, 5383.3t.	76.502
	lignite, 26.5t.	412
Repairs of furnaces & tools		13.162
		113.553f.

No. 12.—*Cost for* 1*t. of Charge.*

Labor,	work, 1.310d	2.066f.
	assistants, 0.203d	0.244
Fuel		7.572
Repairs of furnaces & tools		1.298
		11.180f.

No. 13.—*Cost of Roasting* 2.122*t. of Matte in a Reverb. Furn.*

Labor,	roast's, 604d. at 1.50f.	794.10f.
	labor'rs, 1359d, 1.20f.	1630.80
Fuel	shavings & wood, 31.6t.	316.40
	coal, 17.7t. at 15.15f.	268.15
	coke, 19.6t. at 18.00f.	352.80
	fine coal, 38.4t. at 10.00f.	384.00
Repairs of furnaces & tools		641.00
		4387.25f.

No. 14.—*Cost for Roasting* 1*t. Matte.*

Labor, 0.925d		1.142f.
Fuel	shavings & wood, 0.015t.	0.149f.
	coal, 0.008t.	0.126
	coke, 0.009t.	0.166
	fine coal, 0.018t.	0.181
Repairs of furnaces & tools		0.302
		2.066f.

No. 15.—*Influence of the Zinc.*

Ore of Pb fusion contains.. 8% Zn
Ore for fusion scorias " ..13 to 14% "

To volatilize the Zn, (1854)

Charge	Scorias containing Pb	1200k.
	Roasted ore	200k.
	Ore not roasted	100k.
		1500k.
Pulverized coke		75k.
Fluor		50k.

No. 16.—*Analysis of Scoria & Mattes.*

	Without addition of coke.	With addition of coke.
Matte.		
Fe	36.55	46.54
Zn	13.10	4.65
Cu	5.21	6.70
Pb	9.32	7.98
Scoria.		
Si	34.30	36.00
Al	4.65	3.36
Fe	41.96	40.86
Ca	7.45	7.96
Mg & Mn	1.30	1.75
Cu	0.15	0.18
Pb	0.98	0.73
Zn	7.75	6.66
S	0.80	1.92

No. 17.—*Smelting in the Kilns—Old Method.*

Quantity of scoria with 1000k. of ore.
With cold blast ..... 1,150k.
With hot " ..... 800k.
Quantity of charge in 24h....3t.
" " ore " ....1.4 to 1.5t

No. 18.—*Smelting in Reverb. Furnace, New Method.*

(Proportions in 1852.)

Poor ore.....5 to 10 parts.
Roasted ore .....under 30 parts.
Pb scoria, 100

10t. charge in 24 hours.

Obtained.

2500 to 3000k. matte cont.	Ag,	80 to 160g.
	Pb,	8 to 12%
	Cu,	1 to 3%
Scoria contain'g	Pb,	1 to 1.5%
	Traces of Ag	

No. 19—*Comparison of the two Methods.*

	Rever. Furn.	Shaft Furn.
Charge emp. in 24h.	10½t.	3t.
Labor for 1t. charge	1⅓d.	3d.
Cost of labor.....	2.07f.	4.35f.
Fuel per ton.. coal,	0.532t.	0.33t. coke
Cost fuel per ton....	7.57f.	8f.
Repairs furn. & tools.	1.30f.	0.80–0.90f.
Total cost,	10.94f.	13.20f.

Difference=2.26f. per ton.

No. 20.—*Recapitulation.*

Proportion.

	Poor ore.	Rich ore.
Ore,	544.7k.	455.3k.

For smelting the rich ore, matte, 257.3k.

Products.

Silver Pb.....143.6k.
Matte cont. Pb, ... 29.8
Pb scoria " 534
Speiss " Ag, ... 0.36
Poor ores add to Pb scoria....544.7
Quantity roasted.....251

Products.

Poor scoria.....853k.
Matte.....240k.

No. 21.—*Cost of these Operations.*

Operations.	Labor.		Fuel. Coal.		Coke.		Wood.	
	Days.	Price.	Wt. in ton.	Price.	Weight.	Price.	Weight.	Price.
Roasting Pb ore.....	0.988	1.483	0.098	1.329				
Smelting for Pb.....	1.800	3.100	0.014	0.182	0.221	5.035		
Roast'g ore cont. pyrites.	0.549	0.813	0.052	0.724			0.009	0.091
Smelting of scorias.....	1.631	2.491	0.574	8.166				
Roasting of matte.....	0.237	0.293	0.002	0.003	0.007	0.089	0.004	0.040
	5.205d	8.180f	0.740t	10.434f	0.228t	5.124f	0.013t	0.131f

Operations.	Fluxes Fluor.		Blast & stamps.	Repairs furn. & tools.	Total.
	Weight.	Price.	Price.	Price.	Price.
Roasting Pb ore.....				0.235	3.047
Smelting for Pb.....	0.002	0.036	0.402	0.634	9.389
Roast'g ore cont. Pyrites,				0.012	1.640
Smelting scorias.....				1.301	11.958
Roasting of matte....				0.077	0.532
	0.002t	0.036f	0.402f	2.259f	26.566f

No. 22.—*Loss of Metals.*

	Ag	Pb	Cu
Contained in the ore.....	8536.77k.	1569.86t.	4.29t.
Obtained	8471.00k.	1441.04t.	28.69t.
Difference	65.77k. or 0.77%	128.82t. or 8.20%	24.33=excess
Scorias thrown away contain.	40.34k. or 0.47%	120.85t. or 7.70%	
Real loss by volatilization...	25.43k. or 0.30%	7.97t. or 0.50%	

(3) TREATMENT OE THE LEAD MATTES.

(*a*) 1ST FUSION.

No. 1.—*Fusion of the Matte.*

Depth of crucible of furnace... 0.53m.

Charge for 24h.

	For 1,000k. of matte.
3500 to 4000k. roasted matte.	
800 to 650k. " Cu ore.....200k.	
950k. revivification scoria	240k.
150k. fluor .....40k.	
5750k.	

Scoria from same operation, 500 to 600k.

Coke consumed.

For 1t. matte	0.34t.
For 1t. charge.....	0.25t.

Products obtained.

0.8t. of lead at 630g. of Ag.

1.2t. Cu matte cont. { Ag ..... 200g. / Cu..... 38% / Pb..... 20%

No. 2.—*Analysis of Cu Matte.*

S.....	21.00
Pb	24.80
Fe.....	15.20
Cu.....	36.20
Ag	0.16
Ni, Zn & Sb	2.64
	100.00

No. 3.—*Analysis of Scorias.*

Si	28.05
Fe.....	62.08
Ca.....	3.02
Mg	0.85
Pb & Cu.....	2.67
Al, S & loss.....	4.33
	100.00

(*b*) 2D FUSION.

No. 1.—*Analysis of the Matte.*

Cu.....	53.88
Pb.....	12.32
Fe.....	10.39
Ni, Co & Zn.....	1.18
As & Sb.....	1.53
S.....	18.01
	97.31

No. 2.—*Assay of the Matte,* (1862.)

Ag	210g.
Pb	10%
Cu	50%

Speiss contains,

Cu	40%
Pb	10%
Ni & Co.....	2.5%
Ag	500g.

1st smelting of speiss.

Debris of hearths.....	50%
Scoria of concentration.....	150%
Sulphate of baryta.....	10%
Ni & Co in speiss after 1st smelting	12%

2d smelting of speiss.

Speiss	100
Litharge	400
Scoria of revivification.....	300
Sulphate of baryta.....	10

No. 3.—*Speiss Contains in* 100*k.*

Ag.....30g.	
Cu.....	18%
Co.....	1.84%
Ni	12.65%

No. 4.—Smelting for Concentration of Speiss.

Speiss	100
Sulphate of baryta	50 to 60
Quartz	20 to 25

Amount of Ni & Co after concentration 40 to 44%

(*c*) TREATMENT OF THE SCORIAS.

No. 1.—Analysis of Matte obtained in Smelting Scoria.

S	21.81
As & Sb	0.73
Fe	51.33
Pb	5.69
Cu	11.33
Zn	2.14
O & loss	6.97
	100.00

No. 2.—Assay of this Matte.

Ag	90g.
Pb,	5k.
Cu,	4k.

RESUME.

No. 1.—Treatment in the Shaft Furnace.

Labor including 6 days to light and extinguish fire, 195d.

Employed.	Contained. Ag	Pb	Cu
480.80t. roas'd matte (wt. before roast'g)	1048.60k.	116.145t.	63.536t.
112.44 Cu ore roasted	37.092		15.305t.
The matte produced weighs 109.55t., it is roasted & smelted with:			
11.87 unroasted materials contain'g Cu	47.220		3.849t.
14.65t. fluor			
137.20t. revivification scoria		3%	
91.60t. scoria fr. concentration of matte			1.5%
32. t. Cu containing Pb			
61.45t. matte of revivification at 30g	17.778k.	40%(24.580t.)	16%(9.306
20.65t. scoria "			
10.35t. " of concentration.			
2.90t. fluor.			
5.00t. sulphate of baryta.			
Obtained.	Ag	Pb	Cu
110.25t. Silver lead at 627g	691.075k.		
166.62t. Cu matte at 179g	297.750k.	10%(16.702t.)	44%(74.598t.)
27.50t. speiss cont'g 2.5% Ni & Co 500g.		10%	40%
644.50t. scoria for reverb. furn			

No. 2.—Cost of the Operation.

Labor, roasters, 1204d		1622.00f.
Labor, founders, 1378		2619.00
Fuel.		
Roas'g wood, 3.15t		2072.00
Roas'g coke & fine coal, 54.7		
Roas'g coal, 136.2		
Fusion, charcoal, 0.200t		7488.75
Fusion, coke, 329.360t		
Fluxes, fluor, 17.55t		308.00
Fluxes, BaS, 5.00t		31.00
Stamps		567.00
Blast engine		330.00
Repairs of furn. & tools		1160.00
		16197.75f.

No. 3.—Smelting Scoria in Reverb. Furnace.

Amount of scorias treated.....644.50t.
Labor, including 3d. for repairs...111d.

Employed.		Ag	Cu
518.40	ore cont'g	180.307g.	3.270t.
43.80	scoria containing		3%

Obtained.

Matte at Ag 90g .....264.85t.
Poor scoria at Ag 3.5g.....942.50t.

Metals contained.

	Ag	Pb	Cu
Mat.	238.565k.	5%(13.142t)	4%(10.514t)
Scoria,		0.171k.%	

No. 4.—Cost of the Operation.

Labor, roasters,	890d....	1335.00f.
Labor, founders,	920d....	1656.00
Fuel, roasting	120t. coal ...	1656.50
Fuel, fusion	644t. " ...	9015.00
Repairs of furnaees & tools..		1410.00
		15072.50f.

No. 5.—Loss of Metals.

	Ag	Pb	Cu
Empl'd.	1330.917k.	145.458t.	96.755t.
Obt'ed.	1364.890k.	142.842t.	96.112t.
Differ'ee	33.973k.	2.616t.	0.643t.
or,	2.55%	1.80%	0.685%

RECAPITULATION.

No. 1.—Cost for 1t. of Mattes.

Fusion in Shaft Furnaee.

Labor 5.37d.....		8.820f.
Fuel, coal,	0.283t	3.065
Fuel, wood,	0.007t	0.156
Fuel, coke,	0.800t	16.678
Fluxes, fluor,	0.036	0.640
Fluxes, sulphate baryta,	0.010	0.064
Stamps.....		1.179
Blast engine.....		0.686
Repairs of furn. & tools.....		2.579
		33.867f.

Fusion of the Scorias in the Reverberatory Furnaee & Roasting.

Labor, 3.764.....	6.220f.
Fuel, 1.589.....	22.195
Repairs of furnaee & tools....	2.932
	31.347f.

No. 2.—Cost for working Matte containing Pb.

Labor, 9.134d.....		15.040f.
Fuel, coal,	1.872t.....	25.260
Fuel, wood,	0.007	0.156
Fuel, coke,	0.800	16.678
Fluxes, fluor & baryta, 0.046t.		0.704
Stamps & blast engine.....		1.865
Repairs of furnaees & tools...		5.511
		65.214f.

IMBIBATION.

LIQUATION.

No. 1.—Details of Treatment.

Quantity treated in 24h..... 5 to 10t.

For 1t. of skeletons.

Blaek .Cu.....	600 to 800k.
Crasses.....	400 to 200

No. 2.—Loss.

Cu,	5 to 6%
Pb,	40 to 48%
Ag,	23%

No. 3.—Cost of the Operation.

Pb, 350k. at 500f.....	175.00f.
Cu, 50k. at 2000	100.00
Fuel & labor	25
	300.00f.

AMALGAMATION.

(1) Saxon Amalgamation.
(2) American Amalgamation.
(3) Pan Amalgamation.

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(1) SAXON AMALGAMATION.

No. 1.—*Charge of the Barrel.*

Roasted ore	514k.
Water	154k.
Iron	30 to 50k.
Mercury	257k.

No. 2.—*Barrel at Carson Hill.*

Height of barrel	1.36m.
Diameter "	1.25
Thickness of sides	0.05
Diameter of bottom basins	0.45
Length of Fe or Cu plates	0.50
Width " "	0.25
Charge of ore	250 to 500k.
Charge of Hg	200k.
Time required	3 to 3½h.
No. of men for 4 barrels	1

No. 3.—*Cost at Freiberg.*

Cost for roasting 470k. at 20f.	9.40f.
Fuel for roasting the matte	1.60
Hg, 4409 at 6f	2.64
Sold 100k. at 13.50f	13.50
Fe, 1.20k. at 36f	0.40
Repairs	5.00
Labor, 11d., roasting	3.40
Amalgamation	14.00
Cost of direction	3.20
	53.17f.

(2) AMERICAN AMALGAMATION.

No. 1.—*Expenses.*

Hg, 3.35k. at 14.13f	45.92f.
Stamping	14.36
Grinding	51.45
Amalgamation, labor, 3.50 to 3 horses, 16.60 to 17.16	20.16
Washing	4.30
Distillation	5.75
Magistral & salt, 50 to 75k.	25.85
Rent of works	7.18
Cost of direction	8.82
	189.79f.

MIXED METHOD.

No. 1.—*Details of Operation.*

Charge of ore	2400k.
Salt	150k.
$\dot{F}eS$ or $\dot{C}uS$	36k.
Alum	24k.
Water	600k.

No. 2.—*Cost.*

Labor, 4d. at 0.95f	3.80f.
Magistral, 60k. at 16f	9.60
Hg, 540k at 12f	6.48
Repairs	1.83
Custom house charges	1.46
Transportation of ore	1.21
	24.38f.
182g of Ag extracted	40.4
52g " in residues.	
234g.	
Cost of ore	8.14
Cost of treatment	24.38
	32.52f.

(3) PAN AMALGAMATION.

TREATMENT OF SILVER IN THE WET WAY.

(1) Augustine's Method.
(2) Ziervogel's Method.
(3) Von Patera's Method.
(4) Solution in Acids.

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(1) AUGUSTINE'S METHOD.

No. 1.—*Roasting Furnace at Mansfeld.*

Length of hearth	2.60m.
Width " in centre	2.60
Length of hearth at flue	1.20
Length of the bridge	2.00
Width "	.50
Hearth below top of bridge.	.10
Greatest height of arch	.50
Width of grate	.50
Size of the flue	.40 × .60
Pas'ge fr. low'r to upp'r hearth	.20 × .60
Width of working door	0.70

No. 2.—To treat 3000k. of Matte a year.

Solution tanks	20
Precipitation tanks	24
Furnaces for roasting	9
" " chloruration	4

No. 3.—Cost of the Operation at Freiberg, (1862.)

Roasting & washing.

Labor		56.320f.
Coal,	2.327t	35.255
Salt,	0.173t	25.625
Iron,	0.393t	
HCl,	0.0018	
Repairs		7.450
		124.650f.

Ag in Blk. Cu. 50g.

Loss.

Ag,	12%
Cu,	4%

Smelting of residues containing no Ag.

Labor	9.032f.
Coal, 2.043t	30.951
Repairs	0.950
	40.933f.

Refining of Ag.

Labor	0.245f.
Coal, 0.014t	0.212
Repairs	0.004
	0.461f.

Resumé.

Roasting & washing	124.650f.
Smelting residues	40.933
Refining Ag	0.461
	166.044f.

(2) ZIERVOGEL'S METHOD AT MANSFELD.

Treatment.

No. 1.—Roasting of the Matte of Concentration.

Stamping.

Dimensions of mesh of sieve.	1 to 2m.m.
Ore stamped in 12h	2000k.

Dimensions of the Roasting Furnace.

Length	3m.
Width	0.60
Total length of hearth	3.50
Width at each end	2
" in the middle	3
Height of bridge	0.25
Height of the arch	0.10 to 0.12
Greatest height of arch	0.55
Height of arched conduit	2
Width " "	1.50
Distance of the small conduits	3.30
Height " "	0.70
Temperature on lower hearth	800°
" " upper "	425°

No. 2.—Charge.

Concentrated matte, 250k.

Desilverized residues at 0.002 Ag	35
Large pieces of preced'g opera'n	12½
Residues containing Ag	2

No. 3—1st Period Preparatory Roasting.

Time on upper hearth	5h.

Length of the operations.

Raking	5h.
1st turning over	¼
Raking	1
2d turning over	¼
Raking	2

10k. lignite are added on the lower hearth ¼ to ½

2d Period, Oxydation.

Length of this period	2h.
Temperature of furn. to end op.	400°

Length of each operation.

Raking	1h.
Burning up	¼

3d Period, Complete Roasting.

Length of each operation.

Raking	2h.
Turning over	¼
Raking	¼ to ¾
Time on lower hearth	5h.

No. 4.—Details of the Operation.

No. of furnaces	7
Furnaces working	6
Furnaces in repair	1
Daily product. of a furn.	900 to 1000k.
Wood employed in 12h	225k.
No. of workmen per furn	5
" " lower hearth	3
" " for fireplace	2
Overseer for 2 or 3 furnaces	1
Salary of workmen, per 10h	1.62f.

No. 5.—Dimensions of the Rable.

Length of the rable handle..... 4m.
Weight.....45k.
Rable lasts.....15 to 20d.

No. 6.—Composition of Matte before Roasting.

Cu^2S	65
FeS	8
ZnS	4.30
PbS	1.40
AgS	0.332
Cu	15.
Fe	1.50
Sulphides of Mn, Ni & Co Oxydes of Fe, Pb, Zn & Co,	5
	100.532

It contains:

Metals,	76
Sulphur,	19
Oxygen,	2½
Insoluble residue,	1½
	100

No. 7.—Cost of the Operation.

Charge, 300k.

Stamping of 2000k... ... 6.00f.
" 300k..... 1.00
Fuel, { wood, 222k... 4.50 } 5.10
{ lignite, 30k ... 0.60 }
Labor, { work, at 1.60f. 2.50 } 2.85
{ overseer, ... 0.35 }
8.96f.

Or, per ton, 29.66f.

No. 8.—Washing of the Roasted Matte and Separation of the Ag.

After roasting the matte contains:

Cu,	72 to 75%
Ag,	0.37 to 0.39%

Capacity of the boiler for heating the solution..... 4 to 5c.m.

Basins for solution.

Height..... 0.75m.
Upper diameter..... 0.55
Lower " 0.60
Distance from false bot. to bot. 0.15
Diam. of holes of upper end... 0.012

Dimensions of the rectangular conduits.

Width ..... 0.60m.
Height..... 0.30
Width of basins for precipitation. 0.60
Distance bet. false bot. & bottom. 0.08

Charge of each basin for washing.

Roasted matte.. .... 250k.
Residues containing much Ag.. 30k.
Quantity of water employed.... 85lit.
Temperature of water.....65° to 70°
Time of water on the charge. ½h.
Quantity of sulphuric acid, ½k. for 250k. matte.
Temperature of the solutions. 70° to 75°
Time of charge in the basin ¾ to 1h.
Quantity of roasted matte washed daily in the basin..... 3750k.
When the residues contain 0.0025k. Ag %k. Cu, they are roasted again.
Time of the solution cont. Ag on Cu, 24h

Dimensions of furn. employed to dry Ag.

Length..... 0.55m.
Height..... 0.16m.

Fineness of the Ag obtained, 0.600

No. 9.—Refining of Silver.

Capacity of the bath .....100k. Ag
Impurities contained in refined Ag, 1%

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(3) VON PATERA'S METHOD.

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(4) SOLUTION IN ACIDS.

REFINING SILVER.

No. 1.—Muffle Furnace.

Width ..... 0.92m.
Depth..... 0.84
Height.... ..... 0.76

Hollow for the Ag.

Diameter..... 0.38
Depth... ..... 0.05
Ag contained..... .....29 to 30k.
No. prisms around the hearth. 13
Size of the prisms.....18s.c.m.
Height " 0.15
Interval between the prisms... 0.3
Size of chimney..... 0.3
Time for fusing Ag..... ¾h.
" fining Ag..... 3h.

TREATMENT OF GOLD ORES.

No. 1.—*Analysis of Gold from California.*

	1	2	3	4
Au,	90.9	91.4	89.1	93.
Ag,	8.7	8.5	10.5	6.7
Fe,	0.2	traces.	0.2	traces.
	99.8	99.9	99.8	99.7
Density,	15.7	16.65	17.55	1623

No. 2.—*Composition of Gold Sands.*

	1	2	3
Magnetic Fe,	59.82	34.35	23
Ti with ores of Fe,		15.	50
Mn,	16.32		
Au,	0.29		
Quartz,	13.70	25.	14
Zircons,	9.20	20.	3
Corundum,	0.67	1.	
Chrysoberyl,			10
Other minerals,		4.65	
	100.	100.	180

TREATMENT.

(1) Washing.
(2) Washing and Amalgamation.
(3) Fusion.
(4) Wet Way.

(1) WASHING.

Cost of Treatment.

To move 1c.m.

Ordinary washing	129f.
Rocker	22
Long Tom	6.50
Hydraulic process	1.28

(2) WASHING AND AMALGAMATION.

No. 1.—*Details in Sardinia.*

Ore of mills	82
Loss of Hg for 29.5t. ore	500g
Loss in Au & Ag	28%
Amalgam contained Au & Ag.	17 to 18%

No. 2.—*Composition of the Amalgam.*

Au	72.55 to	75.4
Ag	26.61	23.96
Cu	.84	.74
	100.00	100

(3) FUSION.

(4) WET WAY.

TREATMENT BY CHLORINE.

REFINING OF GOLD AND SILVER AT SEPTEMES.

No. 1.—*Mercantile Products.*

Ag..... .997 fineness.
Au..... .997 "
Sulphate of Cu.

No. 2.—*Treatment of the Substances.*

To be treated directly the amount of Au must be more than .006
To be treated with Cu the amount of Au must be less than .006

Classification of the substances.
1st class, amount of Au, .006 to .750
2d class, " " more than .750

No. 3.—*Smelting for Granulation.*

Charge, 30d. of 1st class substances.
Length of the operation..... 3h.

No. 4.—*Solution.*

Charge of granulated metal. 15 to 17k.
Quantity of S̈ added, 2½ to 3 times the weight of the charge.
Density of the acid..... 50°
Length of the operation..... 2h.
Density of cond'sd sulphuric acid. 27°
" after the concentration..... 50°

No. 5.—*Deposition of the Marcs.*

Temperature of the solution..... 30°
Charge of the basin..... 35k
Density of solution after dissolu'n.. 17°
Distance of the end of the syphon to the bottom of the basin..... 0.25m.

No. 6.—*Precipitation of Ag.*

Length of the operation..... 7h.
Density of the solution of ĊuS̈.... 20°
" when employed for 2d opera'n 24°

Skimming & washing precipitated Ag.
Quantity of Ag..... 30 to 35k.
Length of the operation.... 1h.

Pressing of the precipitated Ag.
Moisture cont. after operation. 8 to 10%

No. 7.—Smelting of Ag.

Weight of the ingots..... 20k.
Fineness " ..... .997

No. 8—Inquartation & Smelting for Au

Wt. of Au cont. in the mares.. 4 to 5k.
Addition of the substances of 2d class.
Density of the acid employed for dissolving..... 50°

No. 9.—Treatment of the substances not containing much Au, with Cu.

Amount of Au, less than..... .006
Smelting with Cu to have a fineness .700
Charge for smelting..... 30k.
Charge for dissolution.....21 to 22k.

No. 10.—Cost for Each Operation.

Smelting for granulation.

6 charges of 30k. or 180k. require:

Coke, 50k. at 45f. for 1000k....	2.25f.
Charcoal, 40k. at 12f. for 100k..	4.80
Plumbago crucible of 40 mares at 0.18f. the mare.....	7.20
Labor.....	3.25
	17.50f.
Or, for 1k. with ordi'ry crucibles,	0.097
With crucibles of best quality,	0.063

Solution.

For 80k. (5 charges) require:

Sulphuric acid at 50° 250k. at 6f.	15.00f.
Lignite, 600k. at 23f. per 100k.	7.80
Labor.....	3.25
	26.05f.
Or, for 1k.....	0.325

When they are poor in Au and are granulated with Cu the expenses are:

Sulphuric acid at 66° 250k. at 14f. per 100k.....	35.00f.
Lignite, 800k. at 23f. per 1000k.	18.40
Labor.....	3.25
	56.65f.
Or, for 1k.....	0.708

Deposition of the Au.

For a charge containing 35k. Ag in solution:

Lignite, 75k. at 23f. per 1000k.	1.72f.
Labor.....	1.62
	3.34
Or, for 1k. of Ag contained,	0.095f.

Precipitation.

Charge of 35k. Ag precipitated requires:

Cu, 10.266k. at 3.25f. per kil.	33.25f.
Lignite, 100k. at 23f. per 1000k.	2.30
Labor.....	0.65
	36.20
Or, for 1k. Ag obtained....	1.037f.

Washing & Pressing of precipitated Ag

35k. of precipitated Ag requires:

Lignite, 25k. at 23f. per 1000k.	0.57f.
Labor.....	1.62
	2.19
Or, for 1k. Ag pressed.....	0.062f.

Smelting with Cu.

For the substances having a fineness of 900%, the addition of Cu must be 200g. to make the fineness 700%

180k. substances to be granulated require

Cu, 36k. at 3.25f. per k.....	117.00f.
Coke, 50k. at 45f. per 1000k.	2.25
Charcoal, 40k. at 12f. pr 100k.	4.80
Crucible of 40m. at 0.18f. pr m.	7.20
Labor.....	3.25
	134.50
Or, for 1k. granulated subst.	0.622f.

No. 11.—Manufacture of $\dot{C}u\ddot{S}$

The production of 900k. mercantile sulphate require:

Lignite, 1000k. at 23f. per ton..	23.00f.
Labor.....	48.75
	71.75
Or, for 100k. sulphate	14.35f.

No. 12.—Comparison of the 2 Methods. (Direct and by Cu.)

Title of the substances taken for example

Ag 0.900 Au 0.006

Costs for 100k. of material treated.

Granulation.....	9.70f.
Solution.....	32.50
Deposition of the mares	9.50
Precipitation of 90k. Ag.....	93.33
Washing & pressing of Ag....	5.58
Smelting of the Ag.....	8.73
Smelting for inquartation 600g. Au & 1.800k. Ag.....	0.05
Dissolving.....	0.03

Washing the Au obtained.....	0.03
Smelting Au	0.05
Manufacture of 40k. sulphate of Cu obtained.....	5.74
	165.24f.
Deduct from the expense:	
40k. sulphate at 120f. per 100k.	48.00
	117.24f.
Or, for 1k. substance to 0.997	1.296

No. 13.—*Costs for the Treatment by Cu.*

Granulation	62.20f.
Solution	70.80
Deposit of the marcs	9.50
Precipitation of 87.500k.....	90.83
Washing & pressing of Ag...	5.42
Smelting of Ag.....	8.48
Manufacture of 184k. sulphate.	26.40
The marcs of Au contain Ag 2k. and Au at 800% 0.600k.	
Wt. of the marcs.... 3.700k.	
Cost for cupellation 2.75f. pr k.	8.52
Cost for the refining of 3.100k. substances at 1.296f. per k..	4.03
	286.18f.
Deduct from the expense:	
184k. sulphate at 120f. pr 100k.	220.80
	65.38
Or, for 1k. substances at 997%	0.726f.

TREATMENT OF TIN.

No. 1.—*Dimensions of Reverb. Furnace.*

Diameter	3.60m.
Angle of hearth.....	$\frac{1}{16}$
Fireplace	0.40 × 1.80
Length of teeth of rake..	0.20
No. revolutions per minute	40
Quantity roasted in 24h..	2t.

No. 2.—*Expense of Roasting in Ordinary Furnace.*

Labor, 2.20d. at 2.29.....	5.76f.
Coal, 765k.....	12.56
	17.62f.

No. 3.—*Treatment with* $\dot{N}aC\ddot{}$.

Quantity of ore treated.....	1050k.
Weight after treatment.....	1000k.
Expense.	
$\dot{N}aC\ddot{}$ 80k. at 30f.....	24.00f.
Coal, 115k. at 20f.....	2.30
Labor, 1.20d. at 3.75f.....	4.40
	30.75
Working & carting.....	25.00
	55.70f.

TREATMENT IN THE SHAFT FURNACE.

No. 1.—*Treatment of* 1*t. of Ore.*

Tin.....	5.25
Scorias.....	4.25
O & loss.....	50
	10.00

No. 2.—*Details of Treatment.*

Quantity treated in 24h.....	1 to 1.5t.
Yield of the ore.....	60 to 65%
Loss of Sn.....	15 to 17%

No. 3.—*Expense of Treatment for* 1*t. of Ore.*

Charcoal, 925k. at 5f.....	46.25f.
Labor, 8d. at 1.50f.....	12.00
	58.25
Sundries & general expenses..25 to 35	
	83 to 93f.

TREATMENT IN REVERBERATORY FURNACE.

No. 1.—*Details of Treatment.*

Quantity treated in 24h....	4t.
Yield of the ore.....	66%
Loss of Sn.....	10 to 12%

No. 2.—*Cost of Treatment.*

Labor, 0.65d. at 3f.....	1.95f.
Cost, 750 at 26f.....	18.75
Anthracite, 250 at 27f.....	6.75
Wood, 1k.....	0.02
Carting & roasting scorias... .	0.42
Repairs, tools, &c.....	1.00
	28.89f.
General expenses.....	26–32
	54–60f

TREATMENT OF ORES OF ZINC.

Treatment.

(1) Silesian Method.
(2) Belgian Method.
(3) English Method.
(4) Treatment in the Wet Way.

(1) SILESIAN METHOD.

No. 1.—Purchase of Ores at Vielle Montagne.

V=purchase price.
R=yield of the ore in the wet way.
E=% of loss in the treatment.
11% of the raw ore.
15% of the calcined ore.
17% with 15% of Silicates.
P=price of 1k. Zn, or about 45% 100k.
T=cost of treatment, or about 8%
D=difference between 45% and the price at the time of purchase.

$$V=(R-E)\ (P-T)+\frac{(R-E)}{2}-(P-D)$$

No. 2.—Calcining the Ores in a Shaft Furnace in Belgium.

Quantity treated in 24h....	13 to 14t.
Loss in weight.....	25%

Expense for 1t. of ore.

Coal, 70 to 100k. at 20f.	1.40 to 2.00f.
Labor, 0.25d. at 2.20f.	0.55
	1.95 to 2.55f.
For 1t. of calcined ore....	2.60f.
With general expenses....	4 to 4.50f.

No. 3.—Calcining Ores in a Shaft Furnace in Spain.

Fuel used.....	8 to 9%
Quantity treated in 24h.....	5 to 8t.
No. of men	6
Loss in weight.....	30%

When 10t. are treated two fireplaces are used.

No. 4.—Calcining in a Reverb. Furn.

Labor, 0.25d. at 2.20f.....	0.55f.
Coal, 87k. at 20f.....	1.74
	2.29
For 1t. of calcined ore....	3.05
With general expenses.....	4.50f.

No. 2.—Roasting Blende.

Crushing the ore.....	1.00f.
Coal, 215t. at 20f.....	4.30
Labor, 1.43d. at 2.2f.....	3.15
Sundries & general expenses....	3.50
	11.95
For 1t. of roasted Blende.....	15f.
Loss in weight.....	18%

No. 6.—Dimensions of the Muffles.

Length	1.17 to 1.45m.
Interior width.....	0.14 to 0.15
Exterior "	0.22
" height	0.55
Interior "	0.28
No. of muffles.....	28–32–48

No. 7.—Quantity of Ore Charged.

For 32 reports, ore.....	1050k.
" 40 " "	1250
" 48 " "	1500
Charge in each report.....32 to 38	
Coal for 1050k. of ore.....	350
Loss allowed for carbonates..	11%
" " Blende	13%

No. 8.—Cost of Treatment.

Labor, 6.7d. at 2.10f.....	14.07f.
Coal for heating 2000 ⎫ 2250 ⎬ at 8.00f " reduction 250 ⎭	19.12
Muffles and condensers.....	4.80
Repairs to furnace.....	2.20
Sundries.....	4.90
	45.09
General expenses.....	10.12
	55.21f.
Coal consumed for 1t. ore prod.	5625k.
Cost for "	1.35 to 1.45f.

No. 9.—Metallurgy of Cadmium.

(2) BELGIAN METHOD.

No. 1.—Dimensions of Muffles.

Length .....1.05 to 1.10m.	
Diameter.....0.15	
Weight of report.....	35 to 45k.
Cost of "	1.75 to 2.00f.

No. 2.—Ore Charged.

No. of reports in furnace	42
Ore charged	500k.
Anthracite	250k.
Charge in each report	11 to 12k.

No. 3.—Cost of Treatment.

Labor, 9d. at 2.05f.	18.45f.
Cost for roasting 1500 } 2000 " reduction 500 } at 11.25	22.50
Muffles, &c	7.00
Repairs	2.92
Sundries	2.00
	52.87
General expenses	10 to 12
	62 to 65f.

(3) ENGLISH METHOD.

(4) WET METHOD.

TREATMENT OF ORES OF MERCURY.

METHOD BY PRECIPITATION.

Expense for 1t. of ore.

Labor, 1.5d. at 1.68f.	2.52f.
Wood, 1000k. at 4.20f.	4.20
Lime, 100k. at 7.50f.	0.75
	7.47f.

METHOD BY ROASTING.

No. 1.—Quantity of Mercury Obtained.

Mercury obtained directly	19.10k.
100k. of mercural soot cont. Hg	5.45
	24.55
Loss	9.45
	34.00f.

No. 2.—Expense of 1t. of Ore at Idria.

Labor, 3d. at 1.14f.	3.42f.
Wood, 200 at 5.50f.	2.49
Reports, 20k. 1.06f.	0.12
Repairs, bricks, &c	0.24
Lime	1.07
Sundries	1.56
General expenses	2.86
	10.76f.

No. 3.—Mercury Obtained in Modified Furnace at Idria.

Mercury obtained directly	15.2
7.8k. of mercural soot	5.7
	20.9
Loss	17.1
	38.0

No. 4.—Expense in Modified Furnace at Almaden.

Charcoal, 16.5 at 5.16f.	0.85f.
Wood	0.09
Labor, 1d	1.10
Transportation	0.97
Sundries	1.58
General expenses	2.86
	7.45f.

No. 5.—Mercury Obtained with the Alberti Furnace, Tuscany.

Mercury obtained directly	6.16
7.3k. of mercurial soot yielding	5.54
	11.70
Loss	2.30
	14.00

No. 6.—Expense with Alberti Furnace.

Wood, 0.40 at 5.53f.	2.21f.
Labor, 1.25d. at 1.14f.	1.42
Retorts, 2.4 at 0.06f.	0.14
Repairs	0.06
Sundries	1.54
General expenses	2.86
	8.23f.

WET WAY.

TREATMENT OF ORES OF ANTIMONY.

Liquation of the ore.

No. 1—*Cost for* 1*t. of Concentrated Ore.*

Coal, 6.50 at 20f.	13.00f.
Labor, 10d. at 1.55f.	15.50
Repairs	2.50
	31.00f.
Loss	20 to 25%

TREATMENT BY ROASTING AND REDUCTION.

No. 1.—*Expense of the Treatment.*

Coal, 1500k. at 30f.	45.00f.
Labor, 10d. at 2.50f.	25.00
Charcoal, 80 at 2.50f.	2.00
45 crucibles, at 0.60f.	27.00
Fluxes, 100k. at 2.50f.	25.00
	124.00
General expenses	76–80
	200–204f.
Antimony in the ore	65%
Quantity extracted	45%

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